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15126



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# MYCOLOGIA

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## GEORGIA PYRENOMYCETES III

J. H. MILLER AND GWENDOLYN BURTON

(WITH 9 FIGURES)

15706

There is a large series of Ascomycetes occurring on dead herbaceous stems during their second summer, and with the exception of *Diaporthe Arctii* (Lasch) Nits., these fall for the most part within the genera *Leptosphaeria*, *Metasphaeria*, and *Ophiobolus*. In the fall and winter following the growing season these stems show a variety of conidial stages, but their relationship with the perfect forms has been worked out only in a very few cases.

Host specificity is seldom found. Many, however, behave as *Ophiobolus anguillides* (Cooke) Sacc. on *Ambrosia artemisiifolia* L.; that is, during July and August it can be found on practically every stem and only rarely on other Compositae.

The so-called perithecia in this group are in reality uniloculate stromata with thick pseudoparenchymatous walls, and asci are embedded in vertically placed paraphysoids connected to the upper wall as well as the base. This is typical of the Pseudosphaeriales order.

The following constitute part of a group that are apparently new to American literature. The rest will follow in later papers.

The types are deposited in the University of Georgia herbarium.

### 1. *Leptosphaeria clavispora* sp. nov. (FIGS. 1-2)

Perithecia scattered, sometimes gregarious, innate, partially erumpent, depressed-globose, black, with slightly papillate ostiola,

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250–500  $\mu$  in diam.; asci arising from base of perithecium, broadly clavate, with thickened apical wall, with very short stalk, immersed in connected paraphysoids,  $98-119 \times 13-14 \mu$ ; ascospores 8, biserial to inordinate, oblong-clavate, straight to slightly curved, with upper end rounded and lower end tapering to a point, 6–10 septate, constricted, light olive brown to dark brown,  $48-51 \times 8-9 \mu$ .

Perithecia sparsa, interdum gregaria, innata, partim erumpentia, depressoglobosa, nigra, ostiolo leniter papillato, 250–500  $\mu$  in diam.; asci ex basi peritheci enati, crasso-clavata, membrana apicibus incrassatis, valde breviter stipitati, in connexis paraphysoidibus immersi,  $98-119 \times 13-14 \mu$ ; ascosporae 8, biserialae vel inordinatae, oblongo-clavatae, rectae vel leniter curvatae, vertice rotundatae et postea attenuatae, 6–10 septatae, constrictae, dilute olivaceo-brunneolae vel atro-brunneae,  $48-51 \times 8-9 \mu$ .

On dead stems of *Eupatorium capillifolium* (Lam.) Small. Campus, University of Georgia, July 1940.

*Leptosphaeria clavigera* (Cooke & Ellis) Sacc. approaches this species in spore shape, but differs in the smaller spores— $25-35 \times 6-8 \mu$ .

## 2. *Leptosphaeria longipedicellata* sp. nov. (FIG. 3)

Perithecia scattered, innate, becoming slightly erumpent, black, sub-conical, with papillate ostiolo, with thick stromatic wall, 250–500  $\mu$  in diam.; asci broadly clavate, apically thickened, with long stipe, arising for the most part from the base of the perithecium, spore part  $80-94 \times 14-16 \mu$ , stipe  $34-58 \times 4-6 \mu$ , embedded in connected paraphysoids; ascospores 8, biserial to inordinate, oblong-fusoid, straight to slightly curved, chiefly dark brown, 3 septate, constricted,  $25-32 \times 6-11.5 \mu$ .

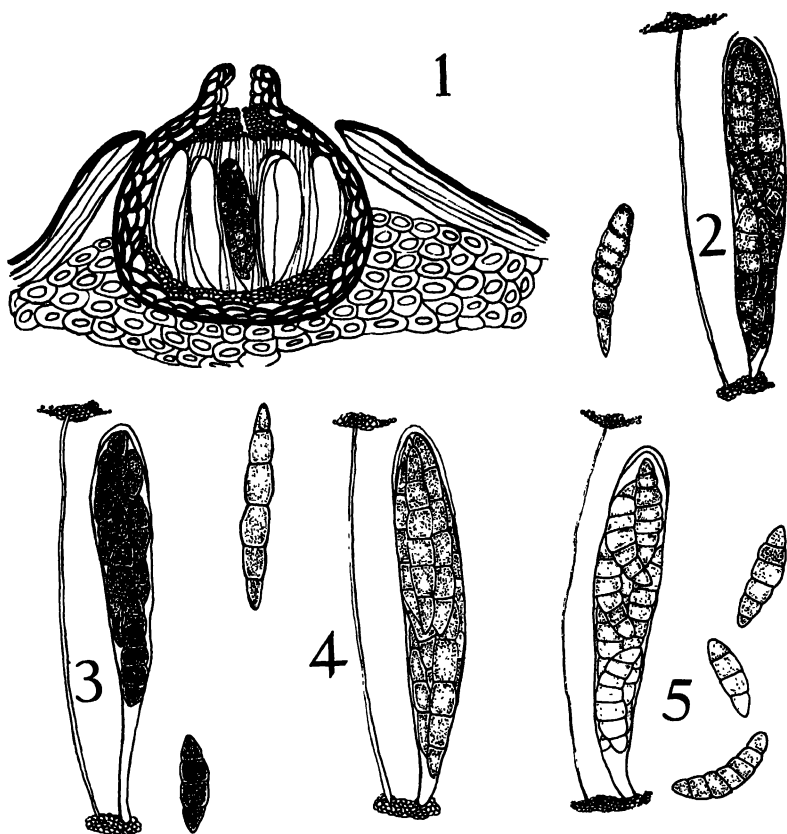
Perithecia sparsa, innata, partim erumpentia, nigra, sub-conica, ostiolo papillato, pariete crasso-stromatico, 250–500  $\mu$  in diam.; asci crasso clavati, apicis incrassatis, longe stipitati, plerumque ex basi peritheciis evoluti, spora parte  $80-94 \times 14-16 \mu$  pedicello  $34-58 \times 4-6 \mu$ , in connexis paraphysoidibus immersi; ascosporae 8, biserialae vel inordinatae, oblongo-fusoidae, rectae vel lenite curvatae, admodum atro-brunnae, 3-septatae, constrictae,  $25-32 \times 6-11.5 \mu$ .

On dead stems of herbaceous plants; *Daucus Carota* L., *Smilanthus Uvedalia* (L.) Mack., and *Solidago Caesia* L. Campus, University of Georgia, July through September 1939.

This species differs from the closely related *Leptosphaeria subconica* (Cooke & Peck) Sacc. and *L. vagabunda* Sacc. in possessing larger ascospores and in the long tapering stalk of the ascus. The latter character is rather rare in the genus.

3. *Leptosphaeria Asteris* sp. nov. (FIG. 4)

Perithecia scattered, innate, partially erumpent in lines, black, depressed-globose with slightly raised ostiola, 300–500  $\mu$  in diam., with very thick stromatic walls, especially at the base; asci widely clavate, with the wall especially thick at the apex, short stalk, aris-



FIGS. 1, 2, *Leptosphaeria clavispora*; 3, *L. longipedicellata*; 4, *L. Asteris*; 5, *L. subcompressa*.

ing from the base of the perithecium, immersed in vertical paraphysoids,  $103-126 \times 16 \mu$ ; ascospores 8, inordinate, elongate, cylindric-fusoid, straight, light brown to dark brown, 5 septate, slightly constricted at the cross walls,  $65-90 \times 8-9 \mu$ .

Perithecia sparsa, innata, partim in lineis erumpentia, nigra, depresso-globosa, ostiolo leniter elevato, 300–500  $\mu$  in diam.; pariete stromatis admodum crasso, plerumque ad basim; asci lato-clavati, membrana apicalis forte in-

crassata, breviter stipitati, ex basi enati, in verticalibus paraphysoidibus immersj,  $103-126 \times 16 \mu$ ; ascospores 8, inordinatae, elongatae, cylindrico-fusoidae, rectae, dilute olivaceo-brunneolae vel atro-brunneae, 5 septatae, leniter constrictae,  $65-90 \times 8-9 \mu$ .

On dead stems of *Aster sagittifolius* Wed. v. *dissitiflorus* Berg. Campus, University of Georgia, April, 1939.

*Leptosphaeria mesoedema* (Berk. & Curt.) Ellis & Ev. is another large spored form on Compositae, but it differs in having a much enlarged central cell that is sometimes divided longitudinally.

#### 4. *Leptosphaeria subcompressa* sp. nov. (FIG. 5)

Perithecia scattered or gregarious in longitudinal series, single or coalesced in a pseudo-stroma, innate, becoming partially erumpent, black, longitudinally compressed, sub-conical with slightly attenuated necks, with rounded ostiola,  $250-500 \mu$  in diam.; asci broadly clavate, apically thickened, with brief stipe, for the most part arising from the base of the perithecium, embedded in connected paraphysoids,  $110-126 \times 20.5 \mu$ ; ascospores 8, biseriatae to inordinate, oblong-fusoid, straight to curved, when mature 5-7 septate, constricted, yellowish,  $30-40 \times 10-12 \mu$ .

Perithecia sparsa vel gregaria in serie longitudinali deposita, singula vel in pseudostromata coalita, innata, partim erumpentia, nigra, longitudinae compressa, sub-conica, colli leniter attenuato, ostiolo rotundo,  $250-500 \mu$  in diam.; asci crasso-clavati, apicibus incrassatis breviter stipitati, plerumque ex basi perithecii evoluti, in connexis paraphysoidibus immersi,  $110-126 \times 20.5 \mu$ ; ascospores 8, biseriatae vel inordinatae, oblongo-fusoidae, rectae vel curvatae, maturae 5-7 septatae, constrictae, flavidae,  $30-40 \times 10-12 \mu$ .

On dead culms of *Andropogon glomeratus* (Walt.) BSP., Campus, University of Georgia, August 1941.

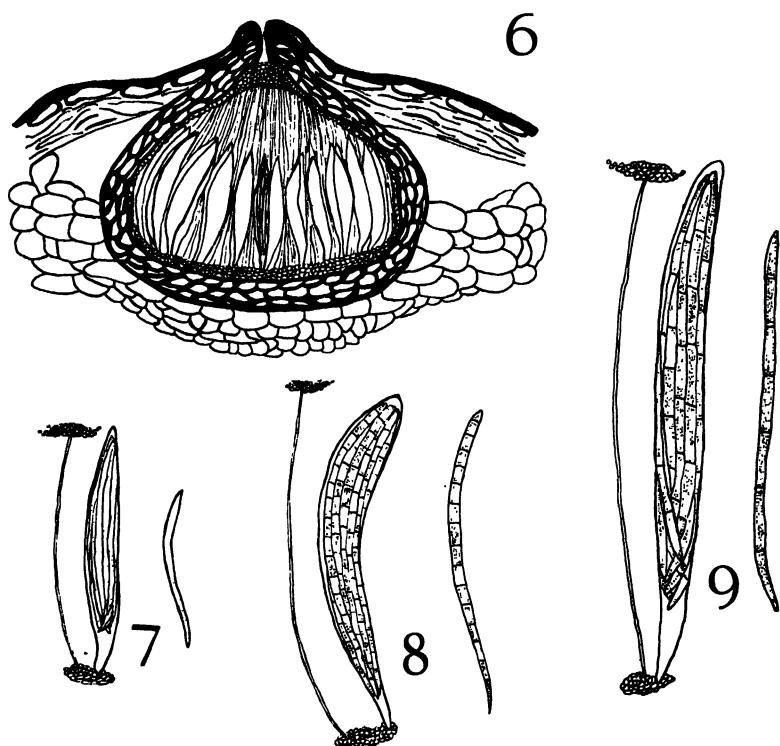
Other species reported on *Andropogon* all differ in possessing much smaller spores. The nearest approach is in *Leptosphaeria latebrosa* (Ellis.) Sacc. with spores  $20-25 \times 3 \mu$ .

#### 5. *Ophiobolus nigro-clypeata* sp. nov. (FIGS. 6-7)

Perithecia aggregated or scattered, depressed-globose,  $350-800 \mu$  in diam., innate, not erumpent, covered by black epidermis, which is pierced by a briefly papillate ostiolar neck, with thick pseudoparenchymatous walls; asci arising from base and sides of perithecium, clavate-lanceolate, with short stipe, immersed in vertical paraphysoids,  $57-70 \times 7-11 \mu$ ; ascospores parallel to irregularly

fasciculate, filiform, not septate, curved when free,  $45-65 \times 3-4 \mu$ , hyaline to light yellowish.

Perithecia aggregata vel sparsa, depresso-globosa,  $350-800 \mu$  in diam., innata, non-erumpentia, nigro epidermide tecta, ex quo ostiola breviter papillata erumpunt, pariete crasse pseudoparenchymato; asci inferne et lateraliter evoluti, clavato-lanceolati, breviter stipitati, in verticalis paraphysoidibus im-



FIGS. 6, 7, *Ophiobolus nigro-clypeata*; 8, *O. Junci*; 9, *O. Cirsii-altissimi*.

mersi,  $57-70 \times 7-11 \mu$ ; ascospores parallelae vel fasciculatae irregulariter, filiformae, non septatae, emersae curvatae, hyalinae vel flavidae,  $45-65 \times 3-4 \mu$ .

On dead stems of herbaceous plants; *Achillea Millefolium* L., *Ambrosia artemisiifolia* L., *Amsonia Tabernaemontana* Walt., *Cassia Chamacrista* L., *Cinicifuga racemosa* (L.) Nutt., *Coreopsis major* Walt., *Coreopsis major* Walt. v. *Oemleri* Britt., *Daucus Carota* L., *Desmodium canadense* (L.) DC., *Desmodium paniculatum* (L.) DC., v. *angustifolium* G. & T., *Firmiana plataniifolia*

(L.) R.Br., *Helianthus microcephalus* G. & T., *Ligusticum canadense* (L.) Britt., *Oxypolis rigidior* (L.) Coult. & Rose, *Smilax laurifolia* L., *Solidago serotina* Ait. Clarke Co., Ga., July to Sept. 1939–1940.

At the end of the section on *Ophiobolus*, Ellis and Everhart (North American Pyrenomycetes, p. 398) cite this species under "Species imperfectly known." This is referred here to *Sphaeria Solidaginis* Fries or *Ophiobolus Solidaginis* Sacc. The writers have compared the Georgia form with the Ellis specimen and they are identical, but as Ellis did not know what Fries had in mind and as it is now impossible to determine his concept with any degree of certainty, it seems best to give this form a new name.

This species differs from all other forms in the genus in that it does not become even partially erumpent, and is always covered by a blackened epidermis that could be called a clypeus. When considered alone this character does not have much taxonomic value. As pointed out in previous papers the most important characters are those found within the perithecial centrum, and as in this case they are entirely those of the Pseudosphaeriales it appears logical to retain it in *Ophiobolus* rather than place it near *Linospora* or *Anthostomella*.

## 6. *Ophiobolus Cirsii-altissimi* sp. nov. (FIG. 8)

Perithecia scattered, innate, finally suberumpent, black, much depressed-globose, with short conic papillate ostiolar neck, with walls of perithecia stromatic and thick, 300–500  $\mu$  in diam.; asci 8-spored, cylindric-clavate, more or less curved, with thick apices, short stalked, arising chiefly from the base of the perithecium, 119–145  $\times$  12–15  $\mu$ , immersed in connected paraphysoids; ascospores parallel, cylindrical, upper end rounded, lower chiefly somewhat attenuated, curved when free of ascus, many septate, not constricted, yellowish to dark brown, 92–136  $\times$  5–6  $\mu$ .

Perithecia sparsa, innata, tandem suberumpentia, nigra, multo depressoglobosa, ostiolo breviter conoideo papillato, pariete perithecii crasso, stromato, 300–500  $\mu$  in diam.; asci octospori, cylindraco-clavati plus minusve curvati, apicibus incrassatis, breviter stipitati, plerumque ex basi perithecii evoluti, 119–145  $\times$  12–15  $\mu$ , in connexis paraphysoidibus immersi; ascosporae parallelae, cylindracae, antice rotundatae, postice plerumque paullo magis attenuatae, emersae curvatae, multiseptatae, non constrictae, flavae vel atrobrunnae, 92–136  $\times$  5–6  $\mu$ .

On dead stems of *Cirsium altissimum* (L.) Spreng. Campus, University of Georgia, July 1940.

This species differs from the other species reported on *Cirsium*, *Ophiobolus acuminatus* (Sow. ex Fries) Duby and *O. Cirsii* (Karst.) Sacc., in possessing much wider ascospores.

## 7. *Ophiobolus Junci* sp. nov. (FIG. 9)

Perithecia scattered, sometimes gregarious, innate, finally erumpent, black, subconical, with truncate papillate ostiolar necks, with thick stromatic walls, 300–800  $\mu$  in diam.; asci numerous, cylindric-clavate, with thick apical wall, short stalked, chiefly arising from base of perithecium, immersed in connected paraphysoids, 8-spored, 138–160  $\times$  14–16  $\mu$ ; ascospores chiefly parallel, cylindric-fusoid, slightly curved, nearly as long as the ascus, chiefly 6-septate, not constricted, yellowish to brown, 115–138  $\times$  4–5  $\mu$ .

Perithecia sparsa, interdum gregaria, innata, tandem erumpentia, nigra, subconoidea, ostiolo papillato-truncato; pariete crasso, stromatico, 300–800  $\mu$  in diam.; asci numerosi, cylindraceo-clavati, membrano ad apicem incrassato, breviter stipitati, plerumque ex basi perithecii enati, in connexis paraphysoidibus immersi, octospori, 138–160  $\times$  14–16  $\mu$ ; ascosporae plerumque parallelae, cylindraceo-fusoidae, leniter curvatae, prope tam longae quam asci, plerumque 6 septatae, non constrictae, flavidae vel fuscae, 115–138  $\times$  4–5  $\mu$ .

On dead stems of *Juncus effusus* L. Campus, University of Georgia, May 1940.

*Ophiobolus juncicola* Rehm differs in having spores 120–150  $\times$  1  $\mu$ .

DEPARTMENT OF PLANT PATHOLOGY,  
THE UNIVERSITY OF GEORGIA,  
ATHENS, GEORGIA

## EXPLANATION OF FIGURES

FIGS. 1–2, drawings of *Leptosphaeria clavispora*. (1, perithecium; 2, ascus and ascospore.); 3, *Leptosphaeria longipedicellata*, ascus and ascospore; 4, *Leptosphaeria Asteris*, ascus and ascospore; 5, *Leptosphaeria subcompressa*, ascus and ascospore.

FIGS. 6–7. *Ophiobolus nigro-clypeata*. (6, perithecium; 7, ascus and ascospore.); 8, *Ophiobolus Junci*, ascus and ascospore; 9, *Ophiobolus Cirsii-altissimi*, ascus and ascospore.

Drawings of asci and spores were made with the camera lucida with an approximate magnification of 365.

# SPORE ORNAMENTATION OF SOME AMERICAN RUSSULAE AND A NEW SPECIES OF LACTARIA

GERTRUDE S. BURLINGHAM

(WITH 14 FIGURES)

The first eight figures accompanying this article show the spore ornamentation of *Russulae* described by the late C. H. Kauffman.<sup>1</sup> As usual the drawings were made with the aid of a camera lucida, using an oil immersion lens and treating the spores with an iodine stain. The magnification is about 1500 times. The spores examined were taken from type specimens.

The following species of *Lactaria* has been found in Florida for several seasons, occurring in abundance through November, and December 1940 and January 1941.

## ***Lactaria maculatipes* sp. nov. (FIG. 9, 14)**

Pileus broadly convex with inrolled margin becoming centrally depressed, finally shallowly infundibuliform with uplifted margin, nearly white at first becoming tinted with honey yellow and closely zoned with deeper yellow, or with alternate rings of white sheen and pale ones of maize yellow (36 tone 2), usually made up of spots rather than of continuous bands, deepening in color with age, very viscid wet, up to 9 cm. broad; margin paler and plainly white-downy; context firm, latex-white, eventually pale yellow on the cut surface, bitter and slowly peppery without odor or slightly pleasant in odor; lamellae flesh color (167 tone 1) singly, deepening with age to chamois color or maize tone 4, unequal, a number forking near the stipe, narrow, close; stipe whitish with many maize yellow scrobiculate spots of various sizes, viscid when wet, becoming hollow, 2.5 cm. to 4 cm.  $\times$  1 cm. to 1.3 cm., equal or slightly narrower at the base; spores fleshy-white tone 1-2, broadly elliptical, echinulate reticulate,  $7.5 \mu \times 8.75-9 \mu$ .

<sup>1</sup> The Agaricaceae of Michigan. 1918.

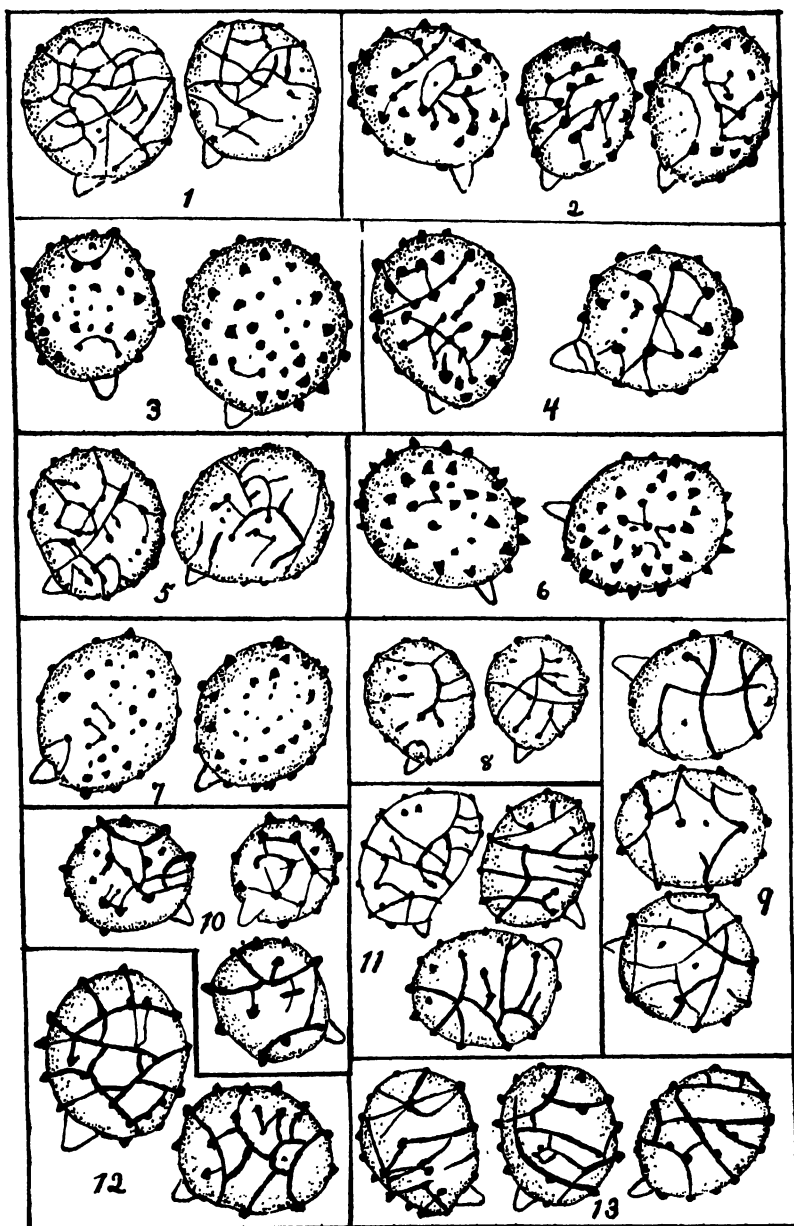


FIG. 1. *R. ochroleucoides*; 2, *R. subpunctata*; 3, *R. borealis*; 4, *R. tenuiceps*; 5, *R. aurantialutea*; 6, *R. sericeonitens*; 7, *R. amygdaloides*; 8, *R. sphagnophila*; 9, *Lactaria maculatipes*; 10, *L. delicata*; 11, *L. chrysorheca*; 12, *L. theiogala*; 13, *L. crocea*.



Pileo late convexo-depresso, postea subinfundibuliformo, zonato, primo albidulo, deinde malleo, zonis maculisve obscurioribus picto, viscoso, margine involuto primitis et albo-puberulo; carne firma subalba, fracta tardissime pallide ochroleuca e lacte, inodora aut odore debili et grato; lacte copioso albo, vix mutante sed sicco pallide ochroleuco, amaro et tarde acri; lamellis carnescoloribus (167 t-1) deinde obscurioribus, inaequalibus, saepe ad stipitem furcatis, angustis, confertis; stipite subalbido, subochroleuco scrobiculato, viscido udo, solido deinde cavo, 2.5 cm.-4 cm.  $\times$  1.2 cm.-1.3 cm., aequalo aut basi leviter constricto; sporis carnealbis echinulatis, reticulatis, late ellipticis,  $7.5 \mu \times 8.75-9 \mu$ .

TYPE LOCALITY: A hammock two miles east of Fort Christmas, Florida.

HABITAT: Under live oaks in moist humus, often gregarious, November through January if rains occur.

DISTRIBUTION: In various places in the same hammock and on Route 24 about three miles North of Apopka, Florida.

This species can readily be distinguished by its pallid closely zoned pileus and scrobiculate stipe and the unchanging latex except as it may in from ten minutes to an hour stain the flesh pale yellow. Rarely does the latex show any change in a drop. From the related species, *L. chrysorhea*, *L. theiogala* and *L. crocea* it differs in this respect as the change to yellow occurs quickly in them. From *L. scrobiculata* it also differs in the lack of tomentum on the margin. In North American Flora I described the stipe of *L. chrysorhea* as sometimes spotted. In my own collections of this species I have never found it so and believe either *Lactaria crocea* or this species may have been confused with it. The species described by W. C. Coker in the Lactarias of North Carolina is evidently not *L. chrysorhea* but possibly *L. delicata* as both of these have a strong odor while *L. chrysorhea* lacks any special odor. His figure on Plate 25 is evidently not *L. chrysorhea*. Spores of *L. chrysorhea* are not pure white as sometimes described but in a mass print are pale blush 137 tone 1, when the spore print is fresh, while those of *Lactaria maculatipes* (FIG. 9) are fleshy-white, larger and more broadly elliptical than in the former species. The spores of *L. delicata* (FIG. 10) are smaller than either of the others, the protuberances larger, and connected by bands as well as some lines, while even under the  $\frac{1}{8}$  power some spines are plainly larger than others. The spores of *L. theiogala* (FIG. 12) are larger than those

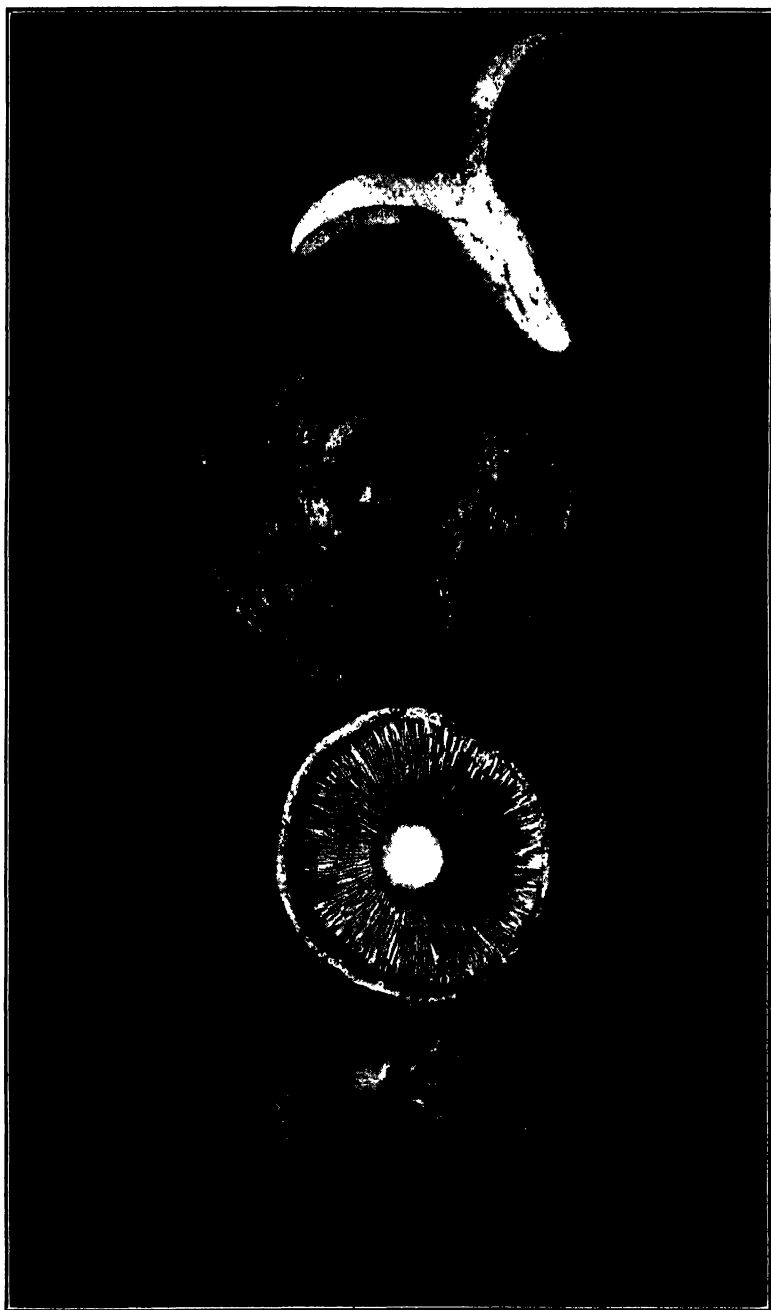


FIG. 14. *Lactaria maculatipes*. Natural size, sometimes larger.

of *L. chrysorhea* (FIG. 11), more broadly elliptical, and have larger protuberances. Hence the spores may be the means of distinguishing between these two species. The spores of *L. crocea* (FIG. 13) are banded with scattered protuberances on the bands, and there are some connecting lines. The spores are slightly larger and more elongated than those of *L. delicata*. They vary in size from  $6.87\ \mu \times 8-9\ \mu$ .

Type specimens of *Lactaria maculatipes* are deposited in the herbarium of the New York Botanical Garden and in my own herbarium.

#### EXPLANATIONS OF FIGURES

FIG. 1, *Russula ochroleucoides* Kauff. Spores globose to subglobose,  $7-9\ \mu$  including the apiculus, with small protuberances connected by lines.

FIG. 2, *R. subpunctata* Kauff. Spores  $6.87-7.5\ \mu \times 8-8.75\ \mu$  exclusive of apiculus ( $7-9\ \mu \times 9-11\ \mu$  including apiculus Kauff.), having fairly large protuberances varying in size with lines connecting some.

FIG. 3, *R. borealis* Kauff. Spores subglobose with protuberances varying in size and some granules with a few very fine connecting lines.

FIG. 4, *R. tenuiceps* Kauff. Spores rather coarsely echinulate, protuberances varying in size, many connected by bands or fine lines,  $6.25\ \mu \times 7.5$  to  $6.87\ \mu \times 7.5\ \mu$  ( $6-8\ \mu$  Kauff.).

FIG. 5, *R. aurantialutea* Kauff. Spores with small protuberances of various sizes connected by thin bands or lines, subglobose,  $7.5\ \mu \times 8-8.75\ \mu$ .

FIG. 6, *R. sericeonitens* Kauff. Spores broadly elliptical, very echinulate, the protuberances varying in size, and a few connected by lines.  $7.5-8\ \mu \times 8.75-10\ \mu$ .

FIG. 7, *R. amygdaloides* Kauff. Spores broadly elliptical having protuberances of different sizes, scarcely any lines appearing.  $7.5-8\ \mu \times 8.75-9\ \mu$ .

FIG. 8, *R. sphagnophila* Kauff. Spores tuberculate with fine lines connecting some protuberances.  $6.25\ \mu \times 7.5\ \mu$ , subglobose.

# STUDIES IN THE GASTEROMYCETES IV. A NEW SPECIES OF GEASTER

W. H. LONG

(WITH 6 FIGURES)

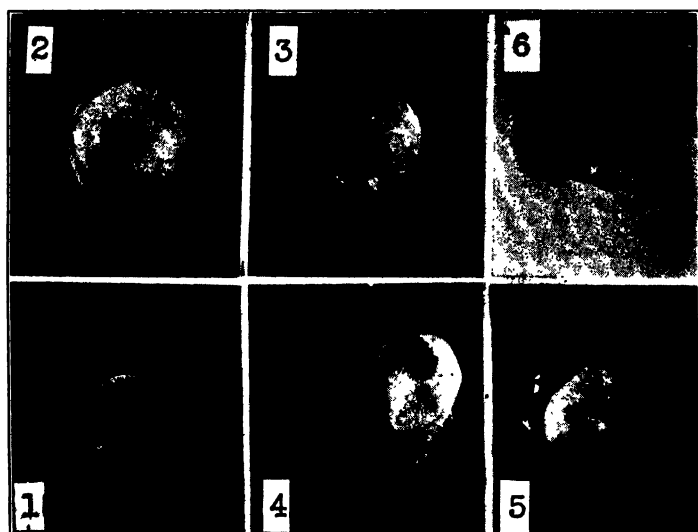
The writer while studying his many collections of Geasters, mainly of material from the southwestern United States, found a sulcate-mouthed plant which apparently does not belong to any known species. A new species is therefore proposed for this *Geaster*.

## ***Geaster xerophilus* sp. nov.**

*Sporophore* hypogeous, small, the button subglobose to strongly depressed-globose or rarely concave on top, 1–2 cm. across, having a strong basal mycelial cord, becoming superficial and expanded at maturity then 1–4 cm. in diameter, usual size about 2 cm. *Exoperidium* saccate (FIG. 1) to explanate (FIG. 2, 3), split to about the middle or rarely to the center in old weathered plants; rays 7–12, pliable, not hygroscopic, unequal, blunt (FIG. 2, 3), tardily expanded or with the tips involute (FIG. 4, 5) around the endoperidium; *fleshy layer* cream buff to cinnamon color,<sup>1</sup> adnate, continuous, rarely rimose; *exterior* covered with sand held by the persistent, thin, strongly adnate mycelial layer which even in very old weathered plants is still retained; base concave with a prominent umbilical scar. *Endoperidium* sessile to usually short-pedicellate, subglobose to strongly depressed-globose, often flattened on top (watch-shaped), 1–2 cm. across, light buff to drab gray when fresh, becoming pallid mouse gray to pale cartridge buff (whitish) with age, densely and minutely furfuraceous (but not asperate), lower  $\frac{1}{3}$  often enclosed by the saccate base of the exoperidium. *Peristome* small, circular or sometimes elliptic (FIG.

<sup>1</sup> All colors used in this article are after Ridgway, R. Color standards and color nomenclature. 1912.

2, 3), acute, sulcate with 18–30 sulci of unequal thickness and length, some not extending to apex of peristome, not seated in a depressed area, concolorous or rarely darker, in age often becoming expanded into a gaping mouth (FIG. 4). *Gleba* mummy brown when fresh becoming snuff brown with age; *columella* prominent (FIG. 6), cylindrical, expanding at top into a persistent globose mass of hyphae; *capillitium* simple, snuff brown under the microscope,



FIGS. 1–6. *Geaster xerophilus*,  $\times 1\frac{1}{4}$ .

4–4.5 microns thick. *Spores* globose, 1-guttulate, 4.2–5 microns in diameter, semi-opaque in water mountant; *epispore* chestnut brown, coarsely verrucose.

**HABITAT:** Solitary or in small groups of 2 or 3 plants, in open, sandy areas or rarely in partial shade of desert plants; in hot dry regions.

**DISTRIBUTION:** New Mexico, Dona Ana County, Jornada Experimental Range, elevation 4150 feet, *Ivan H. Crowell*, February 6, 1937—2 plants no. 8078; *Ivan H. Crowell*, *W. H. Long* and *Victor O. Sandberg*, May 2, 1937—2 plants no. 8182; *W. H. Long*, June 6, 1938—3 plants no. 9295; November 12, 1938—8 plants no. 8285 *Type and 4 plants* no. 8281; October 2, 1939—7 plants

nos. 8400, 8772 and 9378. Lincoln County, 25 miles northwest of Corona, elevation 7100 feet, *W. H. Long* and *David J. Stouffer*, April 20, 1940—2 plants no. 9289. Bernalillo County, near Albuquerque, elevation 5000 feet, *W. H. Long*, June 25, 26 and 27, 1941—6 plants nos. 9362, 9368 and 9370. Sandoval County, 5½ miles west of San Ysidro, elevation 6250 feet, *W. H. Long*, July 9, 1941—19 plants nos. 9379 and 9380; 2 miles south of the town of Bernalillo, elevation 5000 feet, July 12 and 17, 1941—10 plants nos. 9443 and 9453. A total of 63 plants collected to date (July 17, 1941). The above distribution of *Geaster xerophilus* shows a range extending from near Las Cruces in southern New Mexico northward 230 miles in the Rio Grande Valley to Albuquerque, thence southeastward 75 miles to near Corona, then northwestward 50 miles from Albuquerque on State Highway 44. The species probably occurs generally throughout the hot, semi-arid, sandy regions of New Mexico.

*Geaster xerophilus* is the only sulcate-mouthed *Geaster* which is saccate and has a pedicellate spore sac. *G. archeri* is also saccate and has a sulcate mouth, but its spore sac is sessile and not pedicellate.

The type locality of *G. xerophilus* is about 26 miles east of Las Cruces in the Jornada Experimental Range on areas known locally as the "Mesquite-Sandhill" formation, which consists of a succession of sandhills or dunes with tops covered by mesquite brush (*Prosopis glandulosa*), having bare areas and deep depressions between the dunes. The specimens collected were loose in the depressions or on level spots in the sand among the dunes, none were found on top of the sandhills under the mesquite bushes.

A nest of 15 young plants in various stages of development was found in the San Ysidro area buried in loose soil at the base of an old dead sage bush (*Artemisia*). In some the gleba was already brown while in others the color was still white. None of the buttons sectioned had developed any mouths although several were sufficiently mature to have the spore sacs separated from the exoperidium, in such an advanced stage one would expect peristomes to be showing.

The xerophytic habit of *Geaster xerophilus* is unique in this genus. It develops some 1 to 2 inches below the surface of the

sand, with little evidence of decaying vegetation or humus in the soil and usually without any shade. This growth habit is in marked contrast to that of the other species of *Geaster* found in the hot regions of the southwest where the writer has collected hundreds of plants of many different species all growing in the direct shade of trees or desert shrubs; however one species, *G. mammosus*, is often found in partial shade, apparently this species does not require much shade or leaf debris for its development.

All species of *Geaster* in my territory are hypogeous when young and remain so until expansion. I have never seen a truly epigeous *Geaster* in the dry southwestern regions. The reason for this is evident, in that our climate below 8000 feet elevation is too dry for species of *Geaster* to grow on top of the ground as some species do in the humid regions of the north and east. This need of moisture also explains their presence under trees and shrubs where the moisture is retained until these fungi mature.

ALBUQUERQUE, NEW MEXICO

# A SPECIES OF PORIA CAUSING ROT AND CANKERS OF HICKORY AND OAK

W. A. CAMPBELL AND ROSS W. DAVIDSON

(WITH 3 FIGURES)

## INTRODUCTION

Recent investigations of decay in hardwoods have revealed many decay fungi which ordinarily do not produce sporophores on living infected trees (4, 6). Several such fungi, for example, *Polyporus glomeratus* Peck (2) and *Fomes igniarius* var. *laevigatus* (Fries) Overh. (3), usually produce masses of hardened sterile mycelium, often accompanied by cankering, at various heights on the trunks of trees which they infect. These masses of sterile mycelium commonly fill open or partially healed branch stubs or other infection points and may form elsewhere on the trunk, depending upon the progress of the rot within the tree. In time infected trees die and break off at a rot-weakened spot and sporophores develop on the dead standing snags and down logs after a lapse of one to several years.

A rot disease of this type has been observed recently on pignut and shagbark hickories (*Hicoria glabra* (Miller) Sweet and *Hicoria ovata* (Miller) Britton) and on several species of oak.<sup>1</sup> A *Poria*, herein described as *Poria spiculosa*, was collected on down logs and dead, standing trees of hickory and oak (FIG. 1, A). The relationship between this *Poria* and the fungus present in the rot and cankers of living trees was demonstrated by pure-culture methods.

### ***Poria spiculosa* sp. nov.**

Sporophore perennial, effused in patches or in a continuous mass up to 1.5 m. in length on the bark or decorticated surface of thor-

<sup>1</sup> These observations were made in part during visits to farm woodlot improvement plots of the Soil Conservation Service in Region 1. The assistance of the following foresters of the Soil Conservation Service and the Civilian Conservation Corps in obtaining specimens is gratefully acknowledged: A. J. Agar, N. H. Caryll, S. M. Fullerton, V. C. Miles, and R. K. Ziebarth.



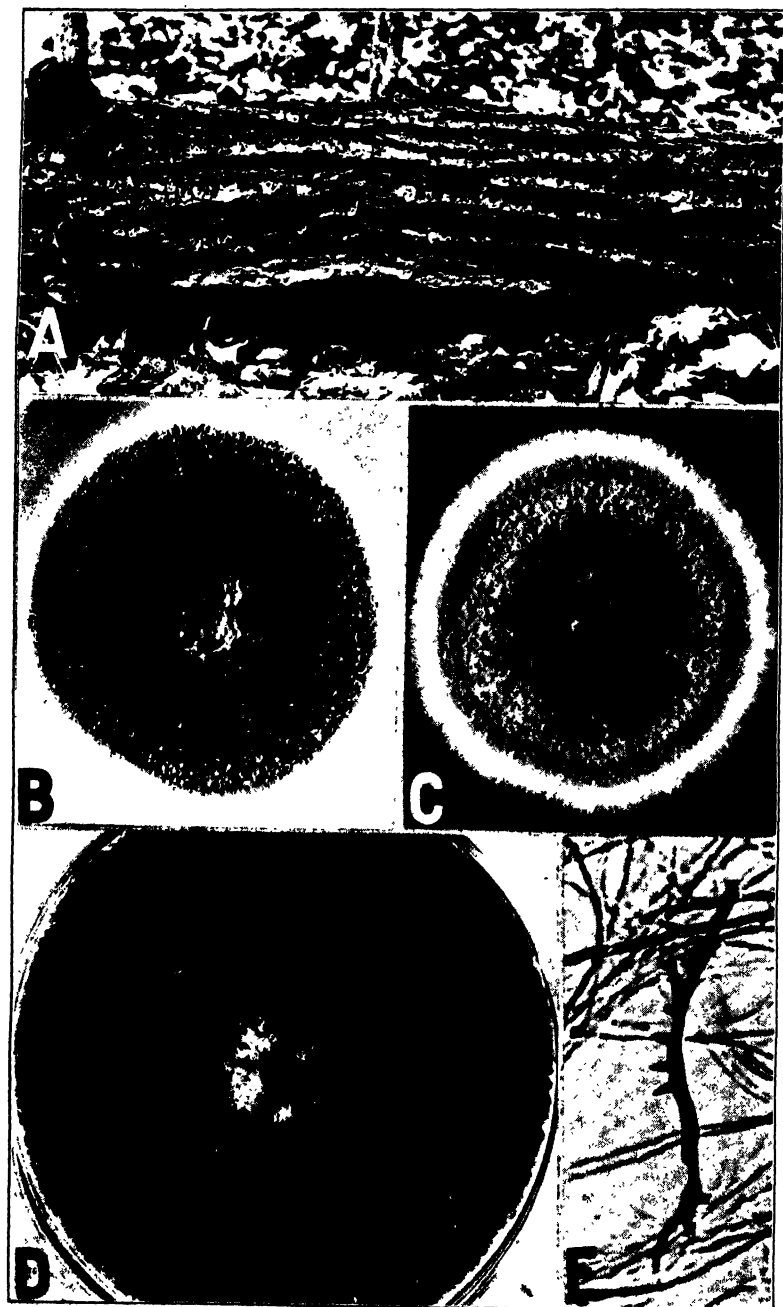


FIG. 1

oughly decayed logs and snags, occasionally on the dead tops of living trees; usually associated with trunk cankers or unhealed branch scars which are filled with masses of sterile fungus material; pore surface brown ("Snuff Brown," "Saccardo's Umber," and "Olive-Brown"<sup>2</sup>), whitish or grayish with age, smooth when young becoming checked and cracked with drying; context brown ("Snuff Brown"), firm but not hard; tube layers distinct, tubes 2-5 mm. long; subiculum thin, usually less than .5 mm. thick, pores 6 to 8 per mm.

Setae few or abundant, often lacking in cross-sections of the tubes but readily seen in longitudinal sections, unevenly distributed, bulbous at the base, not projecting strongly,  $10-20 \times 5-8 \mu$ ; spores hyaline, globose or subglobose,  $3.5-4.5 \mu$  in diameter; hyphae of subiculum smooth, uniformly  $3-4 \mu$  in diameter; yellow or brown; occasional hypha with sharp pointed, short side branches of the type referred to in the description of cultures as "setae-bearing hyphae." These are more abundant but often difficult to demonstrate in the mycelial plugs which fill the space in back of the sterile knots and cankers.

TYPE OF ROT: A white trunk rot of living trees usually associated with cankers or branch scars filled with sterile fungus material.

DISTRIBUTION: On living and dead hickory and oak. Sporophores have been collected in Pennsylvania, Delaware, Virginia, and North Carolina. Type specimen Forest Pathology no. 94090, on shagbark hickory, Saltsburg, Westmoreland Co., Pennsylvania, collected January 1941. The type has been deposited in the Mycological Collections of the Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.

Sporophora perennis, brunnea, juvenilis glabra, vetusta rimosa; tubuli 2-5 mm. longi; subiculum tenue, plerumque minus quam 0.5 mm. crassum; pori 6-8 per mm.; setae paucae vel abundantes,  $10-20 \mu$  longae,  $5-8 \mu$  latae; sporae hyalinae, globosae vel subglobosae,  $3.5-4.5 \mu$ ; hyphae imprimis  $3-4 \mu$  in diam., glabrae, flavae vel brunneae; hyphae setigerae in materia fungosa sterili cancris consociata et interdum in subiculo visae, etiam regulariter in culturis productae.

<sup>2</sup> All colors in quotation marks are from Ridgway (5).

<sup>3</sup> Latin description prepared by Miss Edith K. Cash.

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FIG. 1. A, B, and E. *Poria spiculosa*. A, Sporophore on Underside of hickory log. B, 14-day-old culture. C, 14-day-old culture of *Poria prunicola*. D, 14-day-old culture of *Fomes igniarius* var. *laevigatus* (Fries) Overh. from birch. E, Setae-bearing hyphae from culture of *Poria spiculosa*.

In truncis dejectis erectisque *Illicoriae* et *Quercus* cancris et cicatricibus ramorum materia fungosa sterili impletis consociata.<sup>3</sup>

**CULTURAL CHARACTERISTICS:** Growth medium, forming in 14 days a mat 5 to 7 cm. in diameter; <sup>4</sup> mat appressed, very tough leathery or chamois-like, usually azonate but occasionally somewhat zoned, surface woolly or finely nodulose; mat with exception of a narrow white marginal zone 30 to 50 mm. wide evenly colored "Honey Yellow," "Isabella Color," to "Antimony Yellow" and "Buckthorn Brown;" boundary between colored center and white margin "Pale Orange-Yellow" to "Warm Buff" (FIG. 1, B).

Hyphae from white margin staining in eosin, 1-5  $\mu$  in diameter, sparingly branched, without clamps; non-staining fibrous hyphae colorless, yellow or brown, 1-5  $\mu$  in diameter; setae-bearing hyphae yellow or brown, few or many, usually difficult to demonstrate in older cultures because of the tough leathery mat in which they are embedded (FIG. 1, E).

**DISTINGUISHING CHARACTERISTICS:** *Poria spiculosa*, *Fomes ignarius* var. *laevigatus*, and *Poria prunicola* (Murr.) Sacc. & Trott. are closely related species which cannot be separated on morphological characters of the sporophores. They are however quite distinct in culture. *F. ignarius* var. *laevigatus* (FIG. 1, D) is faster growing than either *P. prunicola* (FIG. 1, C) (1) or *P. spiculosa* and lacks the setae-bearing hyphae of the latter. In addition, cultures of *F. ignarius* var. *laevigatus* kept in the dark often develop a "wintergreen" odor. *P. spiculosa* and *P. prunicola* grow at the same rate in culture but the former produces a very tough leathery mat in contrast to the softer, raised spongy mat of the latter. *P. spiculosa* can be separated from all other brown polypores studied to date by the setae-bearing hyphae which it produces in culture and which are found in the mycelial plugs formed in rotted wood.

These three fungi can be separated fairly consistently on host preference and type of rot. *P. prunicola* appears to be confined to species of *Prunus*, and in *Prunus serotina* produces a red mottled rot of the heartwood unaccompanied by cankers or sterile mycelium. *P. spiculosa* has been noted only on oak and hickory and is usually

<sup>4</sup> Description based on 28 isolates grown in 90 mm. Petri dishes on 2 percent Difco malt agar in diffused light at room temperature.

accompanied by cankering and sterile mycelium. *F. igniarius* var. *laevigatus* occurs on a greater variety of hosts but is most common on *Betula*. Determinations of this species on the basis of cultures have been made on oak and maple. Reports of *F. igniarius* var. *laevigatus* on *Prunus* and *P. prunicola* on hosts other than *Prunus* must be discounted unless the association is proven by cultures.

#### CANKERS AND ROT OF HICKORY

*Poria spiculosa* cankers of hickory vary considerably in appearance, depending upon the size and vigor of the infected tree and upon the age of the canker. The common form on hickory develops around a branch wound and resembles a nearly healed, swollen wound having a well-developed callus which appears to be bursting outward from internal pressure (FIG. 2, A). On large trees these may become prominent burl-like bodies having several vertical or irregular folds in the callus covering (FIG. 2, C). Sterile fungus material is always present in these cankers and often protrudes as an inconspicuous bark-like filling in the cracks between the callus folds (FIG. 2, B and D). An ax cut into the canker exposes a hard black or brown outer fungus crust and a cavity filled with spongy, lightweight, yellow or brown mycelium. Occasionally open cankers develop on the trunk. These usually have a depressed center filled with hardened mycelium and a prominent callus ridge. With age or from other causes this fungus material may disappear from the center leaving a cavity surrounded by raised callus tissue.

A slightly protruding core of fungus material which resembles the remains of a stub sometimes forms in the branch wound of an infected tree. Such evidences of infection are difficult to detect, especially if there is but little stimulation of callus growth around the wound. Manifestations of this type cannot properly be called cankers since there is little or no killing of the cambium. However, these appear to be early stages of infection, and further extension of the rot probably results in the typical canker phase commonly found on older infected trees.

The most characteristic feature of the disease is the yellow or brown mycelial plug which forms in back of the canker and which extends some distance into the rotted wood (FIG. 2, B). This my-



FIG. 2. *Poria spiculosa* in hickory. *A* and *C*, Burl-like cankers which are associated with heartrot. *B*, A longitudinal section through *A* showing heartrot in center of tree and dark brown mycelial mass extending from decay to outer surface. *D*, Burl in *C* with outer surface removed to expose mycelial plugs.

celial plug replaces the decayed wood near the surface and possibly enables the fungus to obtain air by preventing the healing of the infection court. It is formed of tough spongy mycelium composed of smooth yellow or brown hyphae. Irregular dark brown hyphae having short setae-like projections are also present but are not evenly distributed and are often difficult to demonstrate in microscopic mounts made from this material. These are also produced in pure culture by the fungus.

Observations have been made on 25 living infected pignut and 5 shagbark hickories varying in diameter from 4 to 18 inches at breast height. Most of the infected trees had a single canker usually on the lower trunk. One tree had two cankers at heights of 4 and 6 feet respectively, and one had several cankers, the lowest at 3 feet and the highest approximately 15 feet from the ground. Three trees were dissected in order to study the extent of decay and the condition of the cankers. Two had been infected through branch stubs and the third is assumed to have been, although the wounds were too badly decayed to be certain. In the case of trees not dissected, the position of diseased branch wounds point to these as the usual entrance courts for the fungus. Not all cankers indicate separate infections. Badly rotted trees may develop cankers at various heights which are caused by the extension of the decay through branch traces and stubs to the outside bark.

In the advanced stage the rot is soft, powdery, and dry. In earlier stages the rot is soft and white or slightly yellowish, and is sharply delimited from the sound wood. In the trees that were dissected the rot extended from ground line to an average of 12 feet. A single trunk canker probably indicates that the butt log is badly affected and multiple cankers are evidence that the entire trunk is decayed.

No comparative study of hickory decays has been undertaken, but from present observations *P. spiculosa* appears to be one of the most important causes of decay in hickories. Cankered and decayed pignut hickories have been found in North Carolina, Pennsylvania, Virginia, and West Virginia. Infected shagbark hickories have been found in Pennsylvania. This decay probably occurs in hickories in other areas.



FIG. 3. *Poria spiculosa* in oaks. A, Infected branch trace. B, Longitudinal section through infected oak trunk showing decay and mycelial plug back of branch scar. C, Numerous swollen branch scars which are evidence of infection. D, Cross-section of infected trunk.

## CANKERS AND ROT OF OAK

Definite canker formation of the type described as common on hickory was noted less frequently on oak. The usual evidence of *Poria spiculosa* decay consisted of an inconspicuous protrusion of sterile fungus material from a branch trace unaccompanied by pronounced swelling or callusing (FIG. 3, A). This sterile fungus material resembled an ordinary branch stub so closely that a definite diagnosis could be made only by cutting into the branch scar. The cut would reveal an outer hardened fungus crust which was the same color as the oak bark and a softer mycelial plug which filled the space formerly occupied by the branch stub. The cavity usually had only a narrow lining of decayed wood in the outer sapwood. A longitudinal cut through the infected stub revealed the mycelial plug filling the branch opening and its connection with the rotted heartwood (FIG. 3, B).

Open cankers with a depressed center and moderate or slight callusing were occasionally found, especially on willow oak (*Quercus phellos* L.). Burl-like cankers were also found on several oak species. These usually had a roughened surface with many irregular callus folds. The cracks in these folds were filled with sterile fungus material and dissection of the burls showed that these mycelial masses were connected with a central core of rot.

Rot is confined to the heartwood and is typically soft, white, and spongy (FIG. 3, C). Cavities form near branch-stub openings and these are filled with mycelial masses which extend to the outside through branch stubs and cankers. With the extension of rot in the heartwood, sterile masses of mycelium become evident at enlarged branch scars up and down the trunk (FIG. 3, D). All evidence indicates that branch stubs are the usual infection points.

*Poria spiculosa* was not encountered in previous oak decay studies (4) but from recent observations based on external evidence of decay it appears to be one of the more important species in Atlantic Coastal areas on such hosts as *Quercus nigra* L., *Q. phellos*, and *Q. rubra* L. It occurs less frequently in oaks in the mountain regions. It was found in the following species of oaks: Willow oak, Delaware, Virginia, and North Carolina; water oak (*Q. nigra*)



and blackjack oak (*Q. marilandica* Muench.), North Carolina; southern red oak (*Q. rubra*) and other *Quercus* spp., Virginia, and North Carolina.

CIVILIAN CONSERVATION CORPS AND  
BUREAU OF PLANT INDUSTRY, U. S.  
DEPARTMENT OF AGRICULTURE,  
WASHINGTON, D. C.

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# VENTURIA ACERINA, THE PERFECT STAGE OF CLADOSPORIUM HUMILE<sup>1</sup>

A. G. PLAKIDAS

(WITH 3 FIGURES)

On August 30, 1940, while out collecting in the vicinity of Ithaca (near Buttermilk Falls), Professor H. H. Whetzel called attention to prominent spots on leaves of red maple (*Acer rubrum*) which appeared to be distinctly different from any of the common leaf spots of maple. He thought that this might be a new or undescribed disease. A cursory examination of the specimens, disclosing the fasciculate conidiophores and the oblong conidia, suggested that the fungus might be a *Cercospora*. He therefore turned the specimens over to Dr. Chupp, who, in turn, asked the writer to make a critical examination of the material in an attempt to determine the identity of the fungus.

The writer made additional collections of the same leaf spot on red maple on October 2, 1940, near Enfield Glen, N. Y., and again a week later at Watkins Glen, N. Y., on the same suscept. Then on February 28, 1941, in examining various specimens collected near Millinocket, Maine, on August 22, 1940, the same fungus was found on spots on red maple leaves. The spots on the Maine material were, for the most part, small and not typical. Still later, on May 12, 1941, the same spots were found on fallen maple leaves in the Lloyd Preserve, McLean, N. Y. So it is evident that this disease, although not very common, is not particularly rare.

<sup>1</sup> This investigation was conducted at Cornell University while the author was spending his sabbatic year (1940-1941) there under a grant from the General Education Board. The author wishes to express his grateful appreciation to Dr. L. M. Massey, Head of the Department of Plant Pathology, Cornell University, for his kindness in making the facilities of the Department available to him, to Professors H. H. Whetzel, H. M. Fitzpatrick, and Charles Chupp for helpful advice and many courtesies, and to Dr. C. L. Shear for kindly examining specimens and confirming his determination of the generic position of the fungus.

Pieces of leaf tissue from the younger spots were planted on agar, and a gray fungus, which produced conidia in culture (FIG. 2, B) identical with those on the leaves, was easily and repeatedly isolated. The fungus grows well in culture on a variety of media, forming medium-sized colonies gray on top and black in reverse. In addition to this fungus, a species of *Ramularia* (probably *R. lethalis*), and *Sphaeropsis* sp. were occasionally isolated from tissue plantings.

#### DESCRIPTION OF THE DISEASE

The spots (FIG. 1) are numerous, varying in size from very small (0.5–1 mm.) to very large (10–20 mm.). The youngest spots appear as black dots, 0.5–1 mm., round to angular, with a pale-green halo. The older spots are angular to suborbicular, with irregular margins surrounded by a pale-green halo. The upper surface is dark reddish-brown, the lower surface lead-gray. Older spots are zonate, the degree of zonation varying with the size of the spot. The smaller of the older spots are marked by only one narrow ring or zone of light-brown tissue surrounding the darker center. The larger spots may have 2–4 such zones or rings. Coalescence of the spots occurs, forming very large irregular necrotic areas in the leaf. Both surfaces of the spots are covered with a network of light-brown septate mycelium from which arise short, brown, conidiophores bearing oblong to fusoid-cylindric, catenulate, unicellular to 1-septate, olive-brown conidia (FIG. 2, A). Most of the conidiophores arise singly as lateral branches of the surface mycelium, but some arise in fascicles from a more or less tuberculate stroma (FIG. 2, C).

#### IDENTITY OF THE DISEASE

It appeared probable from examination of the literature that the disease under investigation is the same as the maple leaf spot described by J. J. Davis<sup>2</sup> as caused by *Cladosporium humile*. A sample of the Davis collection was obtained from the herbarium of the University of Wisconsin, through the kindness of Dr. H. C. Greene, for comparison with the Cornell material. This specimen

<sup>2</sup> Trans. Wisc. Acad. 19: 702. 1919.

(a leaf of *Acer saccharinum*) was not part of Davis' type material, but represented a second collection made by him at Arcadia, Wisconsin, September 7, 1917. The type collection, which was not examined by the writer, was made from *Acer rubrum*, Luck, Wisconsin, August 25, 1916.

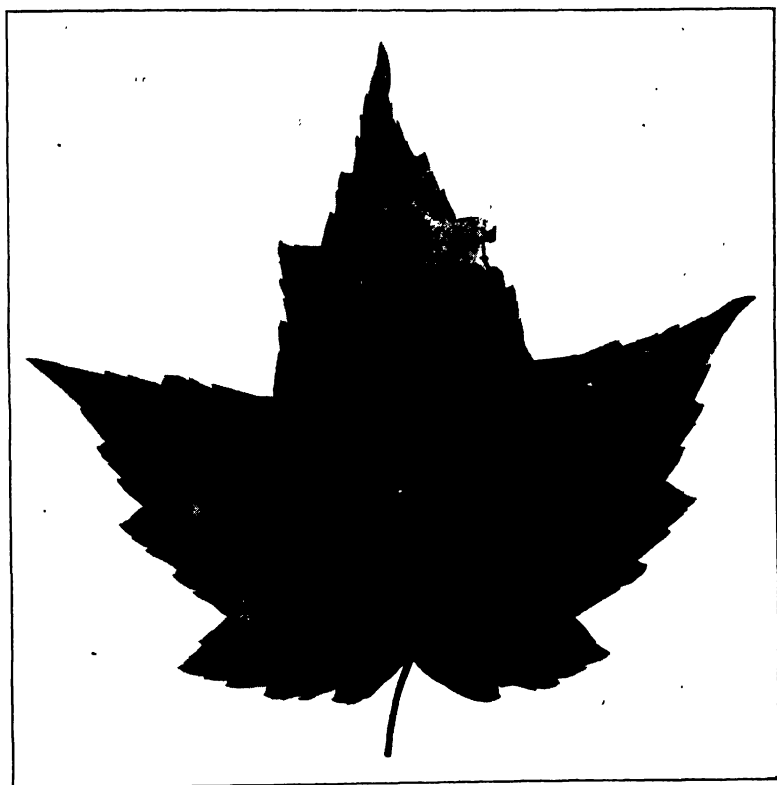


FIG. 1. Leaf of *Acer rubrum* L. showing typical spots,  $\times 1.5$ .

The Wisconsin material proved to be co-specific with that of ours as evidenced by macroscopic symptoms and morphology of the fungus. It was considered desirable to determine how the fungus overwintered, for it was believed likely that its perfect stage would be found if search were made for it. Accordingly, samples of spotted leaves collected in November were placed outdoors in a wire basket and examined periodically during the spring of 1941.

## DISCOVERY OF THE ASCIGEROUS STAGE

The first sample of the overwintered leaves was examined on April 15. Neither conidia nor ascospores were found. The leaves were very dry. Then on April 22, following a week of unseasonable warm weather (the temperature rose to 88.5° F. on April 20) during which intermittent rains fell, a second sample of leaves was examined. Conidia, borne both on fasciculate and on single conidiophores, were found to be fairly abundant. It was not known for certain whether these conidia were old, that is, remnants from the previous late summer and fall, or whether they

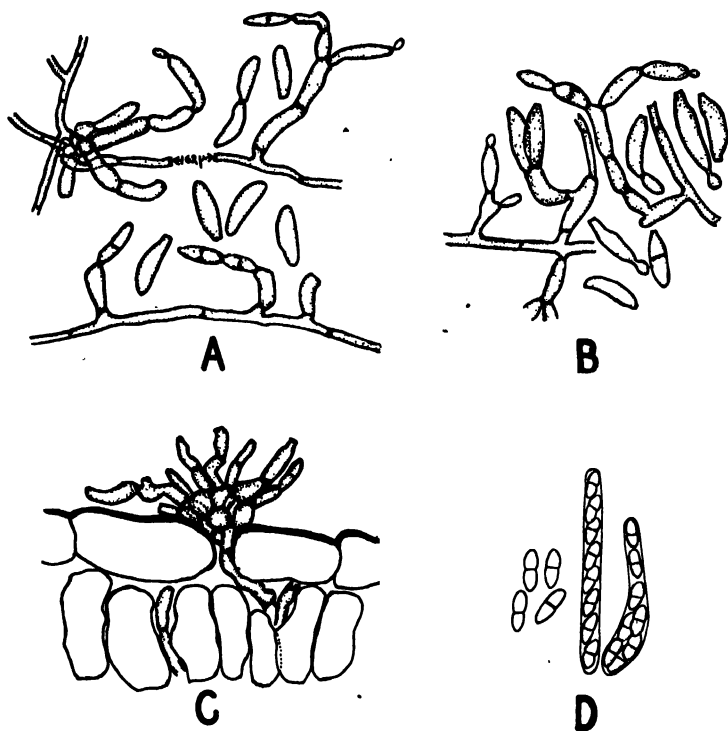


FIG. 2. Conidiophores, conidia, asci and ascospores of *Venturia acerina*. A, camera lucida drawing of mycelium, conidiophores and conidia from the under surface of a leaf spot,  $\times 400$ ; B, camera lucida drawing of mycelium, conidiophores and conidia from a 7-day-old culture on beanpod agar,  $\times 400$ ; C, camera lucida drawing of a paraffin, stained section of leaf showing fascicle of conidiophores on the upper surface and fragments of mycelium in the tissue,  $\times 400$ ; D, asci and ascospores,  $\times 375$ .

had just formed from mycelium overwintered in the leaf tissue. The latter seemed to be true, however, for the conidia appeared fresh and germinated readily when sown on agar. Furthermore, no conidia had been found on the first sample of leaves taken a week earlier during dry weather. It appeared certain that the conidia had developed during the warm, moist weather that prevailed during the preceding week. To test this point further, the leaves were washed in running water with a stiff brush to remove the conidia from their surfaces and placed in a moist chamber. When examined four days later, a new crop of conidia had formed. This procedure was repeated a week later and like results were obtained. Thus it was established that the fungus is able to survive the winter in the mycelial stage in, or on, the leaf and to produce conidia in the spring. This is not the only method of overwintering, for, as will be seen, the fungus also produces ascospores.

On May 8, overwintered leaves which had been washed and placed in a moist chamber a week earlier were examined. Spiny perithecia (FIG. 3), evidently those of a *Venturia*, were found singly or in groups mostly on the under surface of the leaves and around the areas covered by the original spots. The perithecia contained 2-celled, greenish-yellow to light-brown ascospores. Small pieces of the leaf areas bearing the perithecia were cut, stuck on moist filter paper in petri dish covers, and suspended over agar. Ascospores were discharged. Twelve single-ascospore cultures were obtained, and within a week to ten days all produced colonies and conidia identical with those of isolates made from tissue plantings or from sowings of conidia.

Since the overwintered leaves contained, in addition to the spiny perithecia, fructifications of several other fungi (*Mycosphaerella*, *Gnomonia*, *Physalospora*, *Pezizella*, etc.), the procedure described above for obtaining single ascospores was not considered entirely reliable because one could not tell with certainty from which fruit body the ascospores were discharged. Therefore, in another experiment, this method was used: single perithecia were picked out with the point of a needle and crushed in a drop of water on a cover slip. Then, by means of a micromanipulator, single asci, single ascospores, or groups of two or more ascospores,

were transferred to hanging agar drops on cover glasses over hollow slides.<sup>3</sup> After germination, these were transferred to agar slants in tubes.

Cultures were obtained from 4 single asci, 6 single ascospores, and 3 others originating from 2, 6, and 18 ascospores respectively. With a single exception, all cultures produced conidia identical with those of earlier isolations. The one exception was the isolation containing 18 ascospores. In this case, the colony was not transferred but was left on the slide in the hanging drop, and when the drop of agar began to dry, several perithecia, but no conidia, were produced. This was the only instance in which the fungus produced perithecia in culture.

Additional lots of overwintered leaves were examined on May 21 and 30. Conidia, but no perithecia, were found on the leaves as they were brought in from outdoors on both occasions. Perithecia, however, did develop on both lots of leaves after they had remained in a moist chamber 5-7 days. It is believed that the reason perithecia did not develop on the overwintered leaves outdoors was due to the near-drought conditions prevailing in the vicinity of Ithaca in the spring of 1941. The leaves outdoors were dry most of the time during April and May, and, judging by the behavior of the fungus in the moist chamber, prolonged high humidity is apparently essential for its perithecial development.

#### DESCRIPTION OF THE FUNGUS

The most conspicuous character of the fungus is the many prominent, dark-brown bristles covering the upper portion of the perithecium (FIG. 3). For the most part, the bristles are limited to the apex of the perithecium, but often they cover more than half of its exposed surface so that, when viewed from the top with a lens, the perithecia resemble microscopic sea urchins. From the region just below the spines, hyaline to light brown, flexuous, septate hairs of indeterminate length radiate in all directions. Some perithecia are nearly smooth, others have relatively few, short, bristles around the ostiolum, but typically they are decidedly

<sup>3</sup> The writer is indebted to Dr. E. M. Hildebrand who worked the micro-manipulator in making these isolations.

spiny and hairy. In shape the perithecia vary from nearly globose to beaked. There is also considerable variation in the position of the perithecium in relation to the susceptible tissues. Typically, approximately the basal one-half of the perithecium is sunken in the leaf tissue, but it is not uncommon to find perithecia entirely superficial, or completely sunken except for the emergent beaked ostiolar portion. The perithecia are chiefly hypophyllous, but



FIG. 3. Photomicrograph of section of perithecium,  $\times 415$ .

occasionally some occur on the upper surface. The asci (FIG. 2, *D*) are sessile, obclavate at first with the spores imperfectly biserial, elongating and becoming cylindrical, with the spores obliquely monostichous just before discharge. The ascospores are shot out with force from an apical pore. The pore did not turn blue with iodine. The ascospores are hyaline to greenish-yellow, 2-celled, the lower cell usually slightly smaller than the upper, and more or less constricted at the septum. There are no paraphyses, but paraphysoids occur.

The conidial form of the fungus causes definite spots in other-



wise healthy leaves. The conidiophores are amphigenous.<sup>4</sup> They are of two kinds as regards origin. The majority arise singly as lateral branches from a network of superficial mycelium, but they also occur in fascicles on a more or less tuberculate superficial stroma. Most of the fasciculate conidiophores are epiphyllous. Both are brown in color, usually septate, short and rigid to longish and flexuous, straight or geniculate, simple or branched, and bear oblong to fusoid-cylindrical, fuliginous, catenulate, straight to 1-septate conidia (FIG. 2, A-C).

The ascigerous form is obviously a *Venturia*. Dr. C. L. Shear kindly examined specimens submitted to him and confirmed this determination. No mention of *Venturia* on *Acer* has been found in the literature. It is possible, of course, that this fungus has been previously described on another suspect, but in view of our present limited knowledge of the pathogenetic specificity of many fungi, it is considered advisable to describe it as a new species, for which the following name is proposed.

#### TECHNICAL DESCRIPTION

##### ***Venturia acerina* sp. nov.**

Syn. *Cladosporium humile* J. J. Davis, Trans. Wisc. Acad. 19: 702. 1919.

Perithecia scattered or gregarious, chiefly erumpent, occasionally superficial, membranous, dark colored, globose to beaked, typically beset with stiff dark brown non-septate bristles in the region of the apex and with hyaline to light brown septate hairs below (some are nearly smooth), ostiolate,  $72-165 \times 82-191 \mu$ , average  $106.3 \times 132.0 \mu$ ; spines varying in length from  $23.0$  to  $73.0 \mu$  and in thickness from  $4.5$  to  $6.6 \mu$ , average  $41.2 \times 5.7 \mu$ ; asci sessile, obclavate at first with the spores imperfectly biserial, becoming longer and cylindrical at maturity with the spores obliquely monostichous, 8-spored,  $62.7-72.6 \times 8.3-10.0 \mu$ , average  $66.7 \times 9.7 \mu$ ; paraphyses absent; paraphysoids present; ascospores greenish-yellow, 2-celled, the lower cell slightly narrower, with or without constrictions at the septa, oblong elliptic,  $12.5-14.8 \times 4.3-5.0 \mu$ , average  $13.8 \times 4.8 \mu$ . Hab. in fallen leaves of *Acer rubrum* L.

<sup>4</sup> Davis (see footnote 2) states that the conidiophores are epiphyllous. He was obviously mistaken, for conidiophores and conidia were present in profusion on both surfaces of the Wisconsin specimen examined.

TYPE LOCALITY: Ithaca, N. Y., U. S. A.

TYPE SPECIMENS: Type specimens have been deposited in the herbarium of the Department of Plant Pathology, Cornell University (Accession No. 29477), and in the herbarium of the Botany Department, Louisiana State University.

CONIDIAL STAGE: The conidial stage was described as *Cladosporium humile* by J. J. Davis from material on living leaves of *Acer rubrum* L. collected at Luck, Wisconsin, August 25, 1916. Davis also had before him two later collections on *Acer saccharinum* L. from Plover and Arcadia, Wisconsin. Since Davis' description is rather brief, a more detailed description is given here.

Conidiophores amphigenous, arising from a network of superficial hyaline to light brown, coarse, septate, mycelium either singly as lateral branches of the spreading hyphae, or in fascicles from a more or less tuberculate, black, superficial stroma, short and rigid to longish and flexuous, straight or geniculate, septate, simple or branched, fuliginous,  $16.0\text{--}66.0 \times 4.6\text{--}6.6 \mu$ , average  $31.7 \times 5.9 \mu$ ; conidia acrogenous, oblong to fusoid-cylindrical, fuliginous, catenulate, unicellular or 1-septate,  $15\text{--}27 \times 4.6\text{--}6.3 \mu$ , average  $19.8 \times 5.3 \mu$ . On large necrotic spots in living leaves of *Acer rubrum* L. and *A. saccharinum* L.

Since most of the known conidial forms of *Venturia* spp. belong in the genus *Fusicladium*, it would perhaps have been advisable, for the sake of uniformity, to transfer the conidial stage of this fungus to that genus. The line of separation between *Cladosporium* and *Fusicladium* certainly is not very sharp, and, except for its catenulate conidia, this fungus would fit as well in the latter as in the former genus. But since the presence or absence of catenation in the conidia appears to be the chief taxonomic difference between the two genera, it was considered wise to leave the conidial stage of this fungus where it had been placed by Davis.

#### PATHOGENICITY

There can hardly be any doubt that the fungus is pathogenic, for it is always found associated with well-defined lesions from which it can be easily obtained in pure culture. Yet considerable difficulty was encountered in getting infection by artificial inoculation. Early in November, several red maple seedlings were potted

and placed in cold storage to break dormancy, then removed to the greenhouse early in January. By the middle of February, these had plenty of leaves to inoculate. In all, 21 separate inoculations were made between February 20 and May 28, some in the greenhouse and some outdoors, using conidial suspensions from several different isolates. With one exception, the results of the inoculation were either entirely negative, or light infection only resulted. The few spots that developed remained small and atypical. The one exception was in connection with one small potted tree inoculated in the greenhouse on March 23. Hundreds of spots developed on the inoculated leaves of this tree in about 10 days. The tree was removed to the outdoors on May 3, and the lesions continued to enlarge gradually until by July 18, when the last record was taken, the older spots were fairly typical. Conidiophores and conidia were present on these spots, and the fungus was readily reisolated by planting of the spotted leaf tissue.

It is suspected that the age of the leaf may condition its susceptibility. It is probable that senescent leaves are more susceptible than young ones. It is perhaps not accidental that all collections of this disease (Davis', Whetzel's, and the writer's) were made in late summer or early fall. Since the writer had to return to Louisiana, it was not possible to make inoculations in late summer.

#### SUMMARY

A leaf spot disease of the red maple (*Acer rubrum* L.) was collected near Ithaca, N. Y., August 30, 1940, and also near Milinocket, Maine, on August 22, 1940. This disease proved to be identical with that described by J. J. Davis in Wisconsin in 1919 and attributed to *Cladosporium humile*.

A fungus was isolated from the spotted leaves by planting pieces of the spotted tissue and also by culturing single conidia. All isolates thus obtained produced conidia in culture which were identical with those found on the leaf spots.

Infected leaves were collected in November and left outdoors to overwinter. In the spring, when some of the overwintered leaves were placed in moist chambers, perithecia of *Venturia* sp. developed on, and around, the areas occupied by the spots. Single-ascospore

isolations from these perithecia gave cultures identical in every respect with the cultures of *Cladosporium humile* obtained from spotted leaf tissue or from single conidia. Thus, cultural proof has been obtained that the ascigerous stage of *C. humile* is a *Venturia*. This is described as a new species under the name of *V. acerina*.

The fungus produced also conidia on the overwintered leaves in the spring. Thus it appears that the perfect stage is not essential for its overwintering.

DEPARTMENT OF PLANT PATHOLOGY,  
CORNELL UNIVERSITY,  
ITHACA, NEW YORK,  
AND  
DEPARTMENT OF BOTANY,  
LOUISIANA AGRICULTURAL EXPERIMENT STATION,  
BATON ROUGE, LOUISIANA

# VARIATIONS OF SPECIFIC AND VARIETAL CHARACTER INDUCED IN AN ISOLATE OF *BREVILEGNIA*<sup>1</sup>

S. B. SALVIN<sup>2</sup>

(WITH 4 FIGURES)

The genus *Brevilegnia* was established by Coker (1) on the basis of the following characters: (1) the presence of a depauperate dense mycelium; (2) the development of zoösporangia which behaved "about as in *Thraustotheca*" (1, p. 212), *i.e.*, discharged the spores by an irregular rupture of the sporangium wall, which disappeared after maturity; (3) the variability in sporangiospore size and the frequent failure of these spores to emit secondary swarmers; and (4) the formation of small, monosporic oögonia. The type species was *B. unisperma* Coker, the distinguishing characters of which were the presence of many large, long-cylindrical sporangia; the complete disappearance of the sporangial wall simultaneous with the escape of the spores; the development of small, spherical, irregular, one-spored oögonia; the formation of androgynous, profusely branched and irregular antheridia; and the occurrence of zoöspores. Other species and varieties were later described by Coker and others, separated from the type on the basis of such properties as the size and shape of the sporangia, the presence or absence of antheridia, the motility or lack of motility of the zoöspores, and the formation or absence of gemmae.

When an isolate of *Brevilegnia* was obtained by the writer, attempts were made to determine to what species the fungus belonged. However, this was found impossible because of the wide variations in the morphology of the mycelium, asexual structures,

<sup>1</sup> Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 192.

<sup>2</sup> The writer expresses his gratitude to Prof. W. H. Weston, under whose guidance this investigation was conducted, for his valuable suggestions and continued interest.

and sexual bodies, and hence in the general appearance. If a single species of *Brevilegnia* could be so influenced by the environment as to fluctuate in its distinguishing characteristics, the validity of the method of species determination within the genus was obviously worthy of further investigation. In this paper, experiments and observations are presented which demonstrate that from a single isolate the characters of eight different species or varieties of the genus could be obtained by the adjustment of the external environmental conditions, such as temperature, oxygen tension, etc.

#### EXPERIMENTS AND RESULTS

The species of *Brevilegnia* discussed in this paper and referred to as *Brevilegnia* C-2 was collected and isolated from some dried mud, originally lying along a path in Soledad (Cienfuegos), Cuba.<sup>3</sup> From the mycelium resulting from the germination of a single zoospore, a pure culture was obtained, from which sterile hemp seed were inoculated and cultured in glass-redistilled water. The mycelium usually formed a coarse, dense growth, depauperate to extensive, with sporangia borne at the hyphal extremities and renewed by cymose branching. The method by which the sporangia matured and the spores were expelled is the same as that characteristic of the genus, as described in detail by Couch for *B. subclavata* (5).

#### INFLUENCE OF ENVIRONMENTAL VARIATIONS ON THE SPORANGIA.

Although the method of sporangial maturation was the same in the several types of environment, the eventual shape and size of the sporangia varied, depending on the condition of the surrounding medium. The mycelium was grown and formed sporangia in temperatures from 10° to 35° C., in quantities of water from 1 cc. to 2000 cc., in surroundings of both high and low oxygen content, and in various combinations of two or more of these conditions. Only one infected hemp seed was used for each environmental type, although each experiment was repeated several times.

In 50 cc. of well-aerated, glass-redistilled water at 25° C. in a

<sup>3</sup> The writer expresses his thanks to the Atkins Foundation for the grant enabling him to study and collect aquatic fungi at Soledad, and to Mr. Sturrock and Mr. Walsingham for their invaluable aid and coöperation.

four-inch Petri dish, 60.8 per cent of the sporangia (on the basis of 400 measurements) were long, cylindrical, and two spores in width (FIG. 1, *D*); 21 per cent were two spores in diameter at the

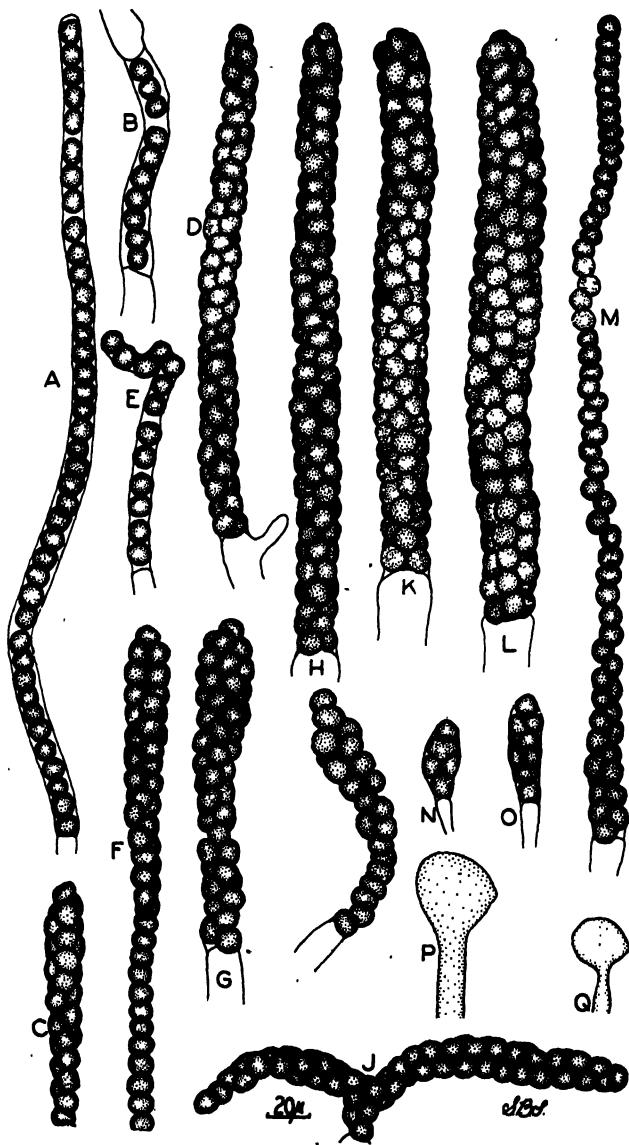


FIG. 1. Camera lucida drawing of different types of sporangia of *Brevilegnia* C-2. (Cf. text for details.)

tip and one at the base (FIG. 1, *F*); and 18.2 per cent averaged three or more spores in breadth (FIG. 1, *K-L*). However, it was found that generally, with temperature and degree of aerobiosis the same, the less water present, the wider the sporangia, and the more water, the thinner the sporangia (FIG. 2). For example, the sporangia developing in 1 cc. of water averaged  $27.2 \mu$  wide (FIG.

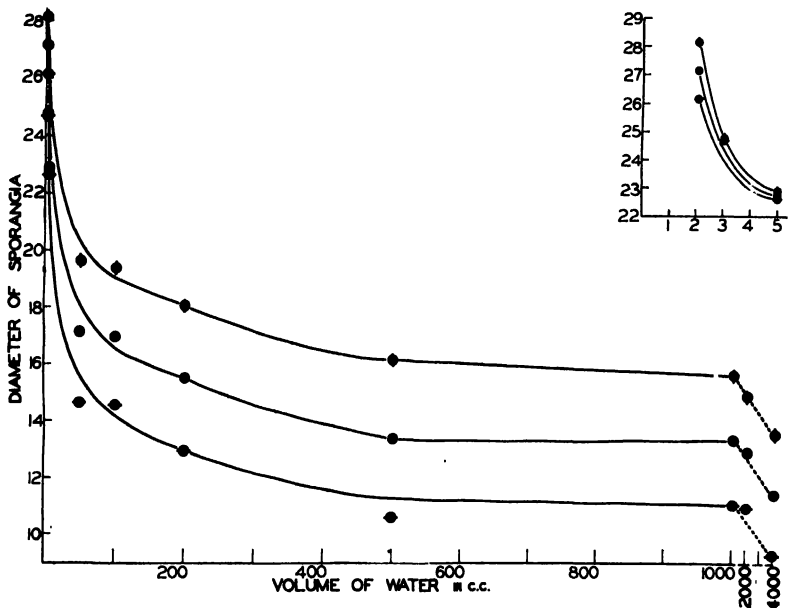


FIG. 2. Graph, showing the relation between the volume of water in which the fungus had been growing and the diameter of the sporangium of *Brevilegnia* C-2.

- denotes the diameter of the sporangial base.
- denotes the diameter of the sporangial apex.
- denotes the diameter of the average of the base and apex.

1, *L*); those in 5 cc.,  $22.8 \mu$  (FIG. 1, *K*); and so on, until those in 4000 cc. were  $11.5 \mu$  wide (FIG. 1, *A, B, E*).

To be sure, even under a constant environment, there were some sporangia that were not of the same type as the majority. For example, in 1500 cc. of well-aerated water at  $25^{\circ} \text{C}$ ., 69.5 per cent of the sporangia were of the same thickness as the hyphae bearing them and had the spores arranged in a single row; 29.5 per cent had a double row of spores at the distal end and a single row at the



proximal; and 1 per cent were two or more spores in width throughout the entire length of the sporangia.

In addition, the temperature of the surrounding water definitely influenced the shape and size of the sporangia. At 35° C., many of the sporangia were not straight, but somewhat contorted or bent upon themselves (FIG. 1, I). The degree of this turning varied from just a slight bending away from the direction in which the hypha was growing to a U-shaped curve which brought the apex of the sporangium to a position near its base.

Also, at 35° C. in 25 cc. of water, an unusual shape of sporangium appeared in moderately large numbers—one which had a double row of spores at its proximal end, then divided into two forks each about two spores in width and bent at almost a 180° angle away from each other (FIG. 1, J).

In general, higher temperatures, *i.e.*, those above 25° C., tended to decrease the diameter of the sporangia, whereas those from 10°–25° C. seemed to have no constant and controlling effect.<sup>4</sup>

Since the above experiments on sporangial variations were started in absolutely pure water, with staling products naturally being formed later, it seemed desirable to study also the type of sporangium formed in a medium containing concentrated staling products. When the fungus was grown in water in which another colony had been developing for 10–14 days and which then had been drawn through a porcelain (Chamberland) filter, the sporangia that ultimately matured were almost exclusively short and clavate (FIG. 1, N, O), with but a few having the spores arranged in a linear series. The number of spores per sporangium was quite small, ranging from four to sixteen in number.

From these results, it seems reasonable to assume that the width and general shape of the sporangia are not very stable and not completely determined by genetic causes, changing not only with the differences in the quality and quantity of the surrounding water, but also varying somewhat within a constant environment. Nevertheless, they have been used as the distinguishing set of factors in the description of three species distinct from the type *Brevilegnia*

<sup>4</sup> In temperatures below 10° C., no sporangia at all were produced, although the ends of the hyphae were swollen and distorted (FIG. 1, P, Q).

*unisperma*—namely, *B. linearis* Coker (1), *B. diclina* Harvey (6), and *B. subclavata* Couch (5) (cf. Table 1). When *Brevilegnia* C-2 was grown in relatively small amounts of water, i.e., 10 cc. or less, at temperatures approximating 20°–25° C., the sporangia were of the type characteristic of *B. unisperma*; when grown in over one liter of water, they were of the type characteristic of *B. linearis*; when grown in water previously inhabited by maturing

TABLE 1  
TO SHOW MAIN CHARACTERS DISTINGUISHING THE SPECIES  
AND VARIETIES OF *Brevilegnia*

| Species and variety                             | Sporangia  | Spore motility                | Antheridia        | Gemmae  |
|---|--|-------------------------------|-------------------|---------|
| <i>B. unisperma</i> ..                          | 23–38×190–350 $\mu$ ; blunt, slightly tapering         | Present                       | Androgynous       | Absent  |
| <i>B. unisperma</i><br>var. <i>litoralis</i> .. | 15–29×140–220 $\mu$                                    | Present                       | Absent            | Absent  |
| <i>B. unisperma</i><br>var. <i>delica</i> ...   | 94–682 $\mu$ in length; spores often in 1–2 rows       | Frequently present            | Absent            | Absent  |
| <i>B. linearis</i> ....                         | Of same thickness as hyphae, with spores in single row | Absent                        | Androgynous       | Absent  |
| <i>B. subclavata</i> ...                        | 30–100×108–140 $\mu$                                   | Absent                        | Androgynous       | Absent  |
| <i>B. diclina</i> .....                         | Spores sometimes in a single row; dense                | Absent (later found by Couch) | Androgynous (few) | Absent  |
| <i>B. megasperma</i> ..                         | In a single row; rarely more than three                | Present                       | Androgynous       | Present |

colonies of the same genus, they were of the type characteristic of *B. subclavata*; and when grown in moderate amounts of water, i.e., about 100 cc., they were of the type characteristic of *B. diclina*.

#### INFLUENCE OF ENVIRONMENTAL VARIATIONS ON ZOÖSPORES.

When the writer first began his study on *Brevilegnia* C-2, although his studies were carried out in hanging-drops of pure, re-distilled water, no motile zoöspores were observed. A few weeks later, however, with conditions as far as known the same, secondary zoöspores were seen emerging from their cysts. Ever since, for a period approximating a year, the normal life-cycle of the spores has been characterized by a period of swarming. Had the writer described the species when it was first studied, he would have typi-

fied it as a form in which zoöspores were lacking. Since then, it would have been described as a form which typically had motile spores.

Yet the rarity of the occurrence of motility was emphasized by Coker (1) in his description of *B. unispërma* var. *delica*, and the total absence by Harvey (6) in his description of *B. diclina*, although Couch (5), in subcultures of Harvey's *B. diclina*, found motility regularly present.

In general, the fundamental basis of activity of the zoöspores is little understood. It is known that certain conditions of the environment, such as the presence of oxygen and minimal concentration of organic and inorganic compounds, must be met in order that the spores may assume a swimming stage, but beyond that our knowledge of the mechanism is extremely slight. Hence, it is the writer's belief that until it is shown that zoöspore activity is influenced more by the genetic character of the organism than by the condition of the environment, species or varieties should not be separated because of the presence or absence of motility in the asexual swarmspores.

#### INFLUENCE OF STALING WATER ON GEMMA FORMATION.

In contrast with the condition in pure water in which no gemmae were produced, gemmae appeared in relatively large numbers on the mycelium of *Brevilegnia* C-2 when the fungus was grown in water containing concentrated staling products, resulting from the growth of twenty colonies of *Brevilegnia* C-2 for 14 days on hemp seed at 25° C. in 25 cc. of water subsequently filtered through a porcelain filter. The thin-walled, densely protoplasmic gemmae were formed either singly in an intercalary fashion (FIG. 3, C) or else terminally in chains up to seven gemmae in length (FIG. 3, A, B, F). In the latter case, they were not all of the same dimensions, but gradually tapered in size from the distal cell, which was up to ten times the diameter of the subtending vegetative hypha, to the extreme proximal one, which was generally from three to five times the diameter of the filament on which it was borne. No special attempts were made to germinate the gemmae, although some were seen giving rise to short hyphae.

Yet, despite the variation in gemma formation which environmental changes induced as shown above, *B. megasperma* was described by Harvey (7) as a distinct species because of the fact that under "normal" conditions gemmae appeared in large numbers (cf. Table 1). However, if this character of gemma formation

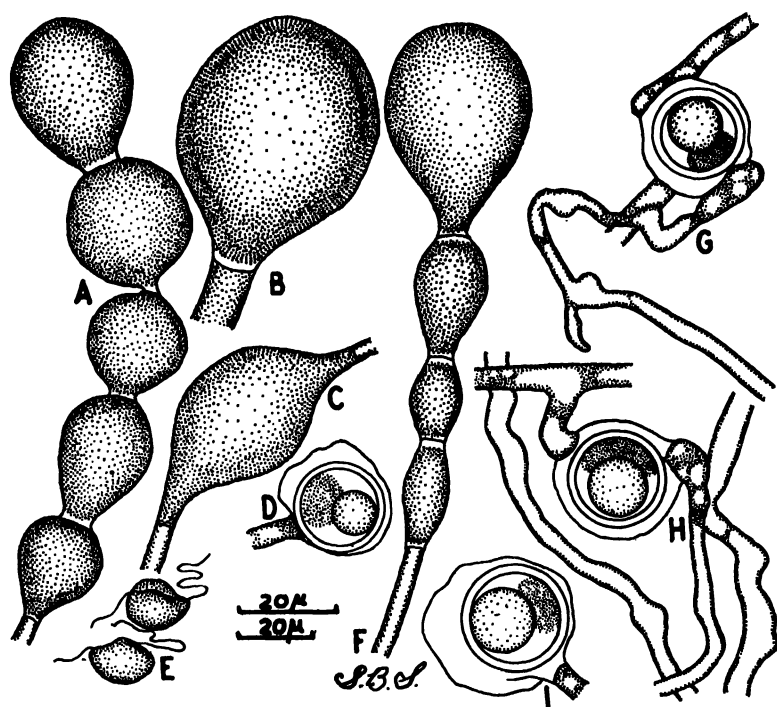


FIG. 3. Camera lucida drawing of gemmae, oögonia, and zoöspores of *Brevilegnia* C-2. (Cf. text for details.)

is partially dependent on the condition of the enveloping medium, its importance in the taxonomic treatment of the genus is greatly lessened. Hence, a species based on the presence or absence of gemma formation is somewhat doubtful.

#### INFLUENCE OF THE ENVIRONMENT ON ANTHERIDIUM FORMATION.

The most important environmental factor that stimulated or hindered the hypha in the formation of antheridia was the quantity of oxygen available. When a hemp seed inoculated with *Brevi-*

*legnia* C-2 was placed at the bottom of a cylinder of water 10 inches high and another seed floated on the surface of a similar depth of water in a second cylinder, there was a great difference in the number of antheridia in the respective positions. The mycelium on the surface of the column of water formed great numbers of

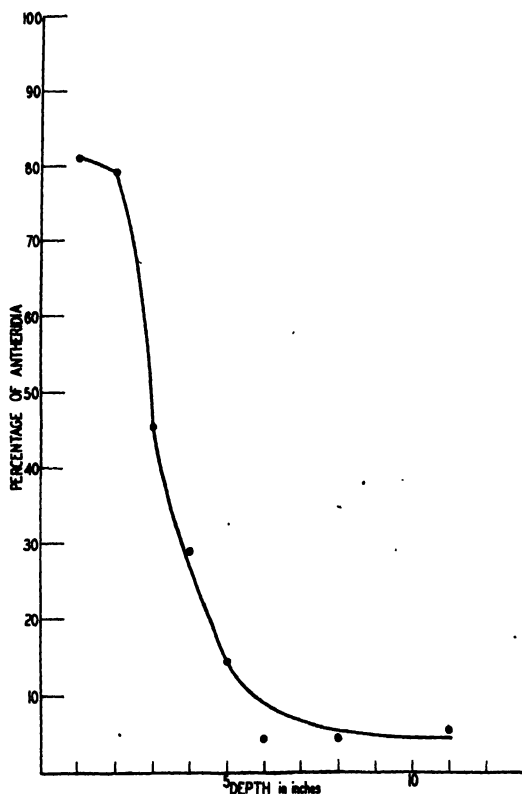


FIG. 4. Graph, showing the relationship between the percentage of oogonia with attached antheridia and the depth of water at which the mycelium developed.

irregular, contorted, hyaline, extensively branched, diclinous antheridia (FIG. 3, *G*, *H*), while the one at the base formed none (FIG. 3, *D*, *I*). Yet, even where antheridia were present, many mature oogonia lacked them, the indication being either that the antheridia were easily detached from the female after fertilization or that the oöspores developed parthenogenetically.

When mycelia were suspended in a 10 inch column of water at intervals of one inch, it was noted that the greater the depth at which the hyphae grew, the fewer the antheridia. Thus, at the surface of the water, 82 per cent of the oögonia had antheridia attached, while at the bottom only about 4 per cent (FIG. 4). The indication is that, in this genus, formation of antheridia is a function controlled not by the genetic constitution of the organism but rather by the degree of aerobiosis of the surrounding medium.

Nevertheless, Coker and Braxton (3) formed a new variety of *Brevilegnia unisperma*, i.e., var. *litoralis*, chiefly on the character that antheridia were absent, whereas they were present in the species (cf. Table 1). According to the results obtained on *Brevilegnia* C-2, such separation of the two forms does not seem advisable.

#### DISCUSSION

The most important character that is used as a key in determining a genus in the Saprolegniaceae is the type of asexual reproduction—that is, the form of the sporangial development, the mode of zoöspore formation, and the extent of the swarmer cycle. In addition, there may be other minor distinguishing properties which may involve a particular manner of sexual reproduction or the extent of vegetative growth. For example, the genus *Geolegnia* is usually marked by a dense, rather limited mycelium, and the species of *Dictyuchus* have mostly a one-spored oögonium. But such characters are of secondary rather than primary significance, and should not be used alone as the main factor in the separation of a genus.

Hence, the main delimiting characters in *Brevilegnia* and the ones which show the minimum amount of variation are the type of sporangial wall and the manner of spore liberation. Except when the sporangia are uni- or biseriate, the spores are liberated not "about as in *Thraustotheca*" (1), but exactly as in *Thraustotheca*. When the sporangia are one or two spores wide, the zoöspores emerge directly from their cysts within the sporangium, resulting in a net-like appearance, as in the genus *Dictyuchus*.

According to Coker et al., the wall of the ruptured *Brevilegnia* sporangium gradually disappears. However, the writer has found evidence to the contrary. Several sporangial fragments over a

week old were killed and stained with chloriodide of zinc, and when examined under a magnification of 1140, a thin sporangial wall was clearly visible. These thinned remnants of the original sporangial wall partially enveloped the groups of spores and undoubtedly in part constituted the structure that prevented those spores within the sporangium from spreading freely through the water and restrained them in groups of varying sizes.

The mechanism for the distribution of the spores of *Brevilegnia* is thus the same as that in *Thraustotheca*, except that in the former the sporangial wall is thinned and weakened to a much greater degree. Since there are no marked differences between *Brevilegnia* and *Thraustotheca*, the evidence indicates that the genus *Brevilegnia* should be reduced to a subgenus under *Thraustotheca*.

The two subgenera would then be separated on the relative thickness of the sporangial wall and the degree to which it disintegrates into various portions partially enveloping the spore masses. The subgenus *Euthraustotheca* would include the species previously described under the genus *Thraustotheca*, whereas the subgenus *Brevilegnia* would contain those forms previously placed in the genus *Brevilegnia*.

Thus, the genus *Thraustotheca* (de Bary) Humphrey may be characterized as follows:

Hyphae stout to slender, branching. Sporangia clavate to subcylindric to very long, often irregular. Primary sporangia formed from swollen ends of hyphae; secondary sporangia proliferating by sympodial branching. Zoöspores when formed encysting within the sporangium and later, in more or less angular form, swelling and escaping (with the exception of those forms that possess sporangia with spores in a single or double row), by irregular rupture or disintegration of the sporangium wall, not escaping at once by an apical papilla except in the *Achlya*-like primary sporangia of two species. Spores escaping from their cysts to swarm in the laterally biflagellate form, to encyst again and finally give rise to a hypha of germination. Oögonia one to several spored with eccentric eggs; antheridia present or absent.

Subgenus *Euthraustotheca*:

Primary threads in greater part stout, branching. Sporangia clavate to subcylindric, often irregular, proliferating from below as in *Achlya*; spores always or in great majority encysting within

the sporangium when formed and later, in more or less angular form, swelling and escaping by irregular rupture or disintegration of the sporangium wall, not escaping at once by an apical papilla except in the *Achlya*-like primary sporangia of one species, *T. primoachlya*. Eggs eccentric, usually multiple. Antheridia present. (Adapted from Coker, 1937.)

Subgenus *Brevilegnia*:

Mycelium dense to spreading. Sporangia in the great majority behaving as in *Euthraustotheca*, the wall becoming very fragile and easily ruptured; in one species, *T. bispora*, sporangia of *Achlya* type also present; spores very variable in size and shape in the same culture, larger ones multinucleate, encysting in position except in the Achlyoid type, and only slowly separating after the disintegration of the sporangium wall; after encystment either emerging and swimming once (dicystic and monoplanetic) with great facility or with utmost difficulty (depending on the form and environment). Gemmae present or wanting. Oögonia small, with a single eccentric egg. Antheridia present or wanting (depending on environment), androgynous or diclinous.

The evidence also indicates the advisability of including *Brevilegnia unisperma* Coker & Braxton, *B. unisperma* var. *delica* Coker & Alexander, *B. unisperma* var. *litoralis* Coker & Braxton, *B. megasperma* Harvey, *B. subclavata* Couch, *B. diclina* Harvey, *B. linearis* Coker & Braxton, and probably *B. unisperma* var. *montana* Coker & Braxton in one species—*T. unisperma* Coker & Braxton. All these species, with the exception of *B. unisperma* var. *montana* in which the oögonial character has not been duplicated, have been approximated in both asexual and sexual features by exposing mycelium of *Brevilegnia* C-2 arising from a single zoöspore to several different external conditions.

At present, such characters as the type of antheridium (androgynous or diclinous), general morphology of the oögonium, or method of sporangial proliferation have not been proved to vary with external conditions, but appear to be genotypically determined. On the other hand, characters such as the size of sporangia, size of oögonia, or occurrence of antheridia, which may show either much variation or intergradation, may be the results of influences either not purely internal, or else unknown.

Thus far, the species *B. bispora* Couch has been purposely omit-



ted from the discussion because of its atypical swarmer cycle. Although distinct from all the other types of *Brevilegnia* in the possession of two types of sporangia, it is similar to *Thraustotheca primoachlya* Coker and Couch. The latter species was separated from the type because of the fact that both Achlyoid and Thraustothecoid sporangia were produced on the same mycelium, and frequently on the same hypha. *Brevilegnia bispora* differs from *T. primoachlya* chiefly in the following respects: absence of motile swarmers in the Thraustothecoid sporangia; presence of great numbers of gemmae, especially under unfavorable conditions; and formation of only one oosphere per oogonium. If one believes that the development of gemmae and the appearance of motile zoospores are factors greatly influenced and partially determined by the environment, the essential differences between *Thraustotheca primoachlya* and *Brevilegnia bispora* lie in the fact that the former has from 1-16 oospheres per oogonium, whereas the latter has only one; and the sporangial walls of the former are somewhat more durable and lasting. Therefore, the writer suggests that for the present both these species should be considered as very closely allied, yet distinct enough to be considered separate. If at some future date, forms are discovered which have an intermediate and intergrading number of oospheres per oogonium, then both of these species should be combined into one.

The conditions under which a fungus grows in nature are quite different from those existing in the laboratory. In a natural environment, morphological variations frequently occur due to the changes in the amount and nature of other proximate organisms, in the range of temperature, in the relative quantity of oxygen, etc. However, under carefully controlled laboratory conditions, variations can be reduced to a minimum. Only then may the properties of a species be determined and described, since comparative studies can be conducted with reasonable certainty.

#### SUMMARY

The genus *Brevilegnia* was established by Coker on the basis of the following characters: (1) the presence of a depauperate dense mycelium; (2) the development of zoosporangia which discharged the spores by the irregular rupture of a sporangium wall that dis-

appeared after maturity; (3) the variability in sporangiospore size and the frequent suppression of motility; and (4) the formation of small, monosporic oögonia. The species and varieties were separated from one another because of such properties as the size and shape of the zoösporangia, the presence or absence of antheridia, the motility or lack of motility of the zoöspores, and the formation or absence of gemmae.

These specific and varietal characters, however, were greatly influenced by the environmental conditions. The width and general shape of the sporangia changed not only with the differences in the quality and quantity of the surrounding water, but also varied somewhat within a constant environment. Zoöspore activity is too little understood to be used as a character for the delimitation of a species or variety. Gemma formation is partially dependent on the condition of the enveloping medium, whereas the appearance of antheridia is controlled by the degree of aerobiosis of the surrounding water.

In addition, the sporangia dehiscenced exactly as in *Thraustotheca* with fragments of the outer wall persisting throughout. Hence, *Brevilegnia* was placed as a subgenus under *Thraustotheca*, and all the species except *T. bispora* included under *T. unispurma*.

BIOLOGICAL LABORATORIES,  
HARVARD UNIVERSITY,  
CAMBRIDGE, MASS.

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# THE MORPHOLOGICAL DISTINCTION BETWEEN UROCYSTIS GLADIOLI AND PAPULASPORA GLADIOLI<sup>1</sup>

H. H. HOTSON<sup>2</sup>

(WITH 3 FIGURES)

Although, Requien (cf. Duby (3)), in 1830, in France, had described a disease of *Gladiolus* as a rust, *Uredo Gladioli*, the correct determination was not made until 1876 when Worthington G. Smith (11), in England, described what was apparently the same fungus on *Gladiolus communis* as a smut disease, *Urocystis Gladioli*. He justly recognized that the sporeballs were clearly related to the smut *Thecaphora* although they greatly resembled the imperfect fungus, *Papulaspora*. However, having secured the opinion of Wittmark and Magnus and of Brefeld, the smut authority, Smith decided that he was correct in placing it in the genus *Urocystis*. In referring to the disease he stated that it was "most virulent in damp, heavy soils" during the wet seasons and that the bulbs seemed to be attacked while in the ground.

In Great Britain, since the work by Smith, Massee (5) recorded it, in 1906, at Kew, Surrey, and in a later article (6) described the sporeballs as 40–50  $\mu$  in diameter. Pethybridge (8) stated that it occurred in Somerset, in 1923; in Yorkshire, in 1932; and, in 1936, on the variety of *Gladiolus nanus*, Peach Blossom, in Devonshire. Moore (7), in 1939, included this fungus in his book on the diseases of bulbs, as a rare disease giving a description and some control measures.

In Continental Europe, Wallroth (12), in 1833, in Germany, recorded it as *Erysibae arillata* var. *Gladioli* (Req.) Wallr., while van Poeteren (10), in 1923–24, found it in Holland on *Gladiolus*

<sup>1</sup> Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 195.

<sup>2</sup> The author wishes to take this opportunity to express his sincere appreciation to Dr. Wm. H. Weston, Jr., for his guidance and constant inspiration.

*nanus* especially on the variety Peach Blossom. Winter (14), in *Die Pilze*, in 1881, described this fungus and stated that it was found on *Gladiolus communis* and *Gladiolus imbricatus*. A brief description was given by Pape (9), in 1927, in Germany, in which he reported the disease on *Gladiolus communis*, *G. nanus*, *G. imbricatus*, *G. segetum*, and *G. bucheanus* (?), also stating that it had been reported from England, Holland and France. He stated that the disease showed symptoms on the stalk or rhizome in the form of black pustules or blisters which raised the epidermis. J. I. Liro (*i.e.* J. I. Lindroth) (4), in 1922, called it *Tuburcinia Gladioli* (Req.) Liro, basing this change on his conception of the genus *Tuburcinia* Fries in which he included many species previously in *Urocystis*. Thus, the synonymy, if we accept *Urocystis Gladioli* (Req.) Smith as the proper name, is *Uredo Gladioli* (Req.), *Erysibae arillata* var. *Gladioli* (Req.) Wallr., *Tuburcinia Gladioli* (Req.) Liro.

In the United States, C. C. Wernham (13), in 1938, in Pennsylvania, isolated from *Gladiolus* sp. a fungus which he called *Urocystis Gladioli* (Req.) Smith, but which, unlike smuts of that genus, germinated readily to mycelium on potato-dextrose agar. Zundel (15), in 1939, reported *Urocystis Gladioli* (Req.) Smith, in Erie Co., Pennsylvania, on *Gladiolus* sp. (cult.). He also reported it from the Province of Saskatchewan, Canada. Since both men reported the same disease, caused by the same fungus, from the same locality, the fungi probably may be assumed to be identical even though Zundel does not mention germinating the sporeballs in culture. B. O. Dodge and Thomas Laskaris (1), in 1941, isolated what they thought to be the smut disease of *Gladiolus* from diseased bulbs from Long Island, N. Y., and, doubting that it was a smut, stated that this fungus seemed to be a *Papulaspora*. In a later paper (2) they determined this was a *Papulaspora* but thought it the same as the European material, even though they were unable to compare them. Nevertheless, they called their fungus *Papulaspora Gladioli* (Req.) Dodge and Laskaris. They add: "If Requien's type is a leaf smut the combination would simply be *Papulaspora Gladioli* (Smith)." The writer, however, assumes on the basis of evidence presented here that Smith's material is the same as Requien's.

Now, the writer has been able to make the necessary comparison of these two organisms, *Urocystis Gladioli* (Req.) Smith and *Papulaspora Gladioli* (Req.) Dodge and Laskaris, and, as a result, is convinced that they are two separate entities. The evidence for this conclusion is presented in the following paper.

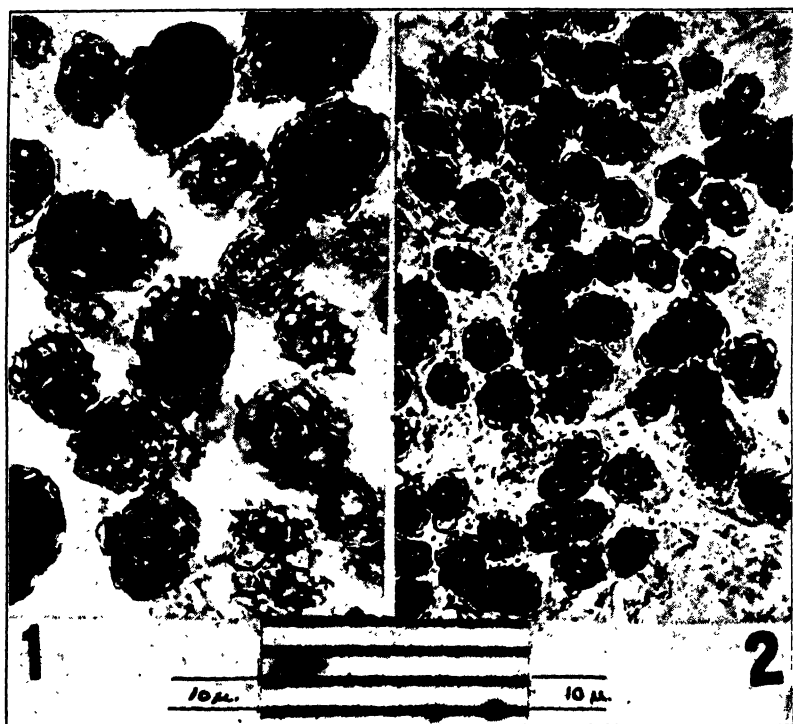


FIG. 1. Sporeballs of *Papulaspora Gladioli*; 2, Sporeballs of *Urocystis Gladioli*. Both at the same magnification. (400 X.)

Culture material of *Papulaspora Gladioli* from the laboratories of B. O. Dodge plus some additional isolations of *Papulasporas* from diseased corms of *Gladiolus* from Long Island, N. Y., comprise the material upon which the writer has based this comparative study. The European material, from collections by G. H. Pethybridge, in Langeport, Somerset, England, in 1923, was made available through the courtesy of E. M. Wakefield of the Royal Botanic Gardens at Kew. From this material, originally pickled when col-

lected in 1923, a small portion was dried and sent the writer in 1941. This was prepared in glycerine mounts for study, while the American material was grown in culture and studied both living and in glycerine mounts.

On critical examination, the most important structure, the sporeballs, were found to be in sufficiently good condition in this English material, for adequate comparison with the American material. The following distinction, as seen in figure 1, are at once apparent. First, the sporeballs are distinctly different in size; *Urocystis Gladioli* measures from 14–23  $\mu$  in diameter while *Papulaspora Gladioli* has the extreme ranges of from 24–64  $\mu$  in diameter with the average at 44  $\mu$  (FIG. 3). This, in itself, is not significant unless one considers the variation in size. The European material has been reported in the literature as ranging from 40–50  $\mu$  in diameter with the average at approximately 45  $\mu$ , while the specimen of *Urocystis*, received from England, is confined within much narrower limits. Second, the definiteness of the sterile periferia of *Urocystis Gladioli*, as shown in figure 2, is more striking than that of *Papulaspora Gladioli*. In *Urocystis Gladioli*, the single row of thin-walled cells is characteristic of the genus and the definite thickness of the wall of the inner cell is very distinct. In *Papulaspora Gladioli*, on the other hand, the periferia is not always sterile and is more or less indefinite, being often composed of more than one layer of cells, indefinitely and irregularly arranged. Finally, the central cells in the *Urocystis* range from 1–2 in number while those in the *Papulaspora* are customarily 2–6 or, exceptionally, 6–8 in number.

Due to the fact that the European material has been preserved for nearly eighteen years, certain of the morphological characters unfortunately are valueless for this comparison. The mycelium has degenerated and as the material is not living a germinative study cannot be made.

Even more significantly different than the foregoing morphological distinctions are the unlike reactions of these two fungi on the host. As was mentioned above, *Urocystis Gladioli* causes, on the stalk and rhizome, black pustules which contain the sporeballs of the smut. The symptoms are clearly those of a smut. On the other hand, *Papulaspora Gladioli* is found as a saprophyte in the

cracks in the corms as arachnoid mycelium bearing the discernible bulbils.

Hence, in Europe, there seems to be an organism, *Urocystis Gladioli* (Req.) Smith, which attacks the corms and stalks of several species of *Gladiolus* causing blisters or pustules filled with sporeballs. The disease was very bad in England, according to

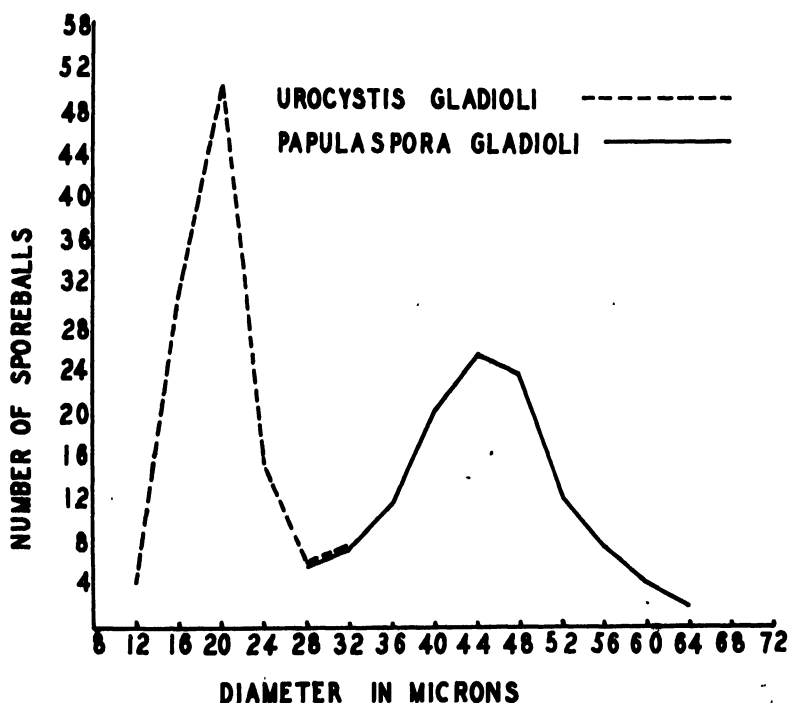


FIG. 3. Graph showing relative sizes of sporeballs of *Urocystis Gladioli* and *Papulaspora Gladioli* each based on 200 sporeballs measured at random.

Smith, but has been gradually decreasing in severity until, in 1939, Moore spoke of it as rare. In the United States, there is a fungus, *Papulaspora Gladioli*, which is not parasitic or only slightly so, and does not cause pustules or blisters on the corms or stalks, but is found in the cracks of diseased *Gladiolus* bulbs which have already been infected by some other organism.

Such being the case, this *Papulaspora* on *Gladiolus* is not a synonym for *Urocystis Gladioli* (Req.) Smith, as the two are distinct.

It seems necessary, therefore, in view of the confusion, to establish it as a separate entity. An excellent diagnosis has been recently published by B. O. Dodge and T. Laskaris (2) so that it is unnecessary to repeat it here.

***Papulaspora Gladioli* sp. nov.**

For complete diagnosis see the article by B. O. Dodge and T. Laskaris (2). In addition it may be noted that the average diameter of the bulbils is  $44\mu$  and the bulbil primordium is a lateral branch, sometimes coiled in one plane but never a spirile.

In view of the existing confusion between these two fungi, any conclusions must at present be based on certain assumptions.

Assuming that Pethybridge's material is the same as that of W. G. Smith's and that they both are the same as Requien's, then it seems that there exists a true smut disease, *Urocystis Gladioli* (Req.) Smith, in Europe, and that this has not been reported in the United States. The identification by W. G. Smith seems dependable since he consulted three outstanding mycological authorities prior to publication, and the possibility that Brefeld would not know a *Urocystis*, after his extensive studies in this group, seems unlikely, particularly when he was confronted with the possibility that it might be either a *Papulaspora* or a *Tubercinia*. There is some evidence, however, that in addition there may well be a *Papulaspora* in Europe which has been confused with *Urocystis Gladioli* for there are notable discrepancies in the published sizes of the European material in comparison with that of the material sent the writer from Kew. This also adds to the confusion and until someone is able to get type material of W. G. Smith's *Urocystis Gladioli* from the British Museum the significance of these differences cannot be ascertained with certainty. The material which was thought to be the smut disease in this country is in reality various species of *Papulaspora*, as will be shown in a later paper. These American forms do not cause a disease but are merely saprophytes following a primary infection of some other fungus, often *Sclerotinia (Botrytis)* sp.

The evidence, therefore, seems to the writer sufficient grounds to justify the conclusion that these two fungi are separate entities



and that this European fungus on *Gladiolus* is a *Urocystis* while those in America are *Papulasporas*. Also, that *Papulaspora Gladioli* is a separate species, not one which has previously been described, and it is distinct from any of the species, subsequently described by the author, which will appear in a later paper.

However, until such time as living material of *Urocystis Gladioli* (Req.) Smith has been studied and a comparative life history worked out, the problem in its entirety must go unanswered.

BIOLOGICAL LABORATORIES,  
HARVARD UNIVERSITY,  
CAMBRIDGE, MASS.

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# PHACIDIUM NIGRUM

EDITH K. CASH

(WITH 1 FIGURE)

Among recent collections from Florida made by Dr. C. L. Shear and referred to the writer for determination were several specimens of a Phacidiaceous fungus on leaves of *Xolisma ferruginea* (Walt.) Heller which proved on examination to be identical with type material of *Phacidium nigrum* Cooke in the Mycological Collections of the Bureau of Plant Industry. Two additional specimens of the same species were also found in the Collections under another name. *P. nigrum* was described from material found by Ravenel in 1881 at Darien, Georgia, and except for Cooke's description in Grevillea (1, p. 23) and its translation in Saccardo, no reference in literature to its occurrence has been found. It seems desirable, therefore, to supplement the brief original description with further details.

On leaves and twigs of *Xolisma ferruginea*, scattered or densely crowded and forming a black crust; spots on leaf margins sub-orbicular or irregular, later covering a large part of the leaf surface, avellaneous<sup>1</sup> to sayal brown, later fading to drab gray, often shading to pale vinaceous drab or purple drab near the border; stromata in epidermal layer, cells of epidermis and central tissue of leaf disintegrated by mycelium; sterile stromata epiphyllous, scattered or crowded, partially emergent but usually remaining covered by the lacerate epidermis, fragments of which often remain attached by one edge in the form of a lid; apothecia developing singly from fertile hypophyllous stromata, scattered or grouped along the mid-rib and veins, or closely crowded and covering a large portion of the leaf, also often surrounding and incrusting the small twigs, elliptical in outline or irregular from mutual pressure, fleshy to carbonaceous, 1–2 mm. in diameter, surface dull black, roughened,

<sup>1</sup> Color nomenclature is that of Ridgway, R., Color standards and color nomenclature. Washington, 1912.

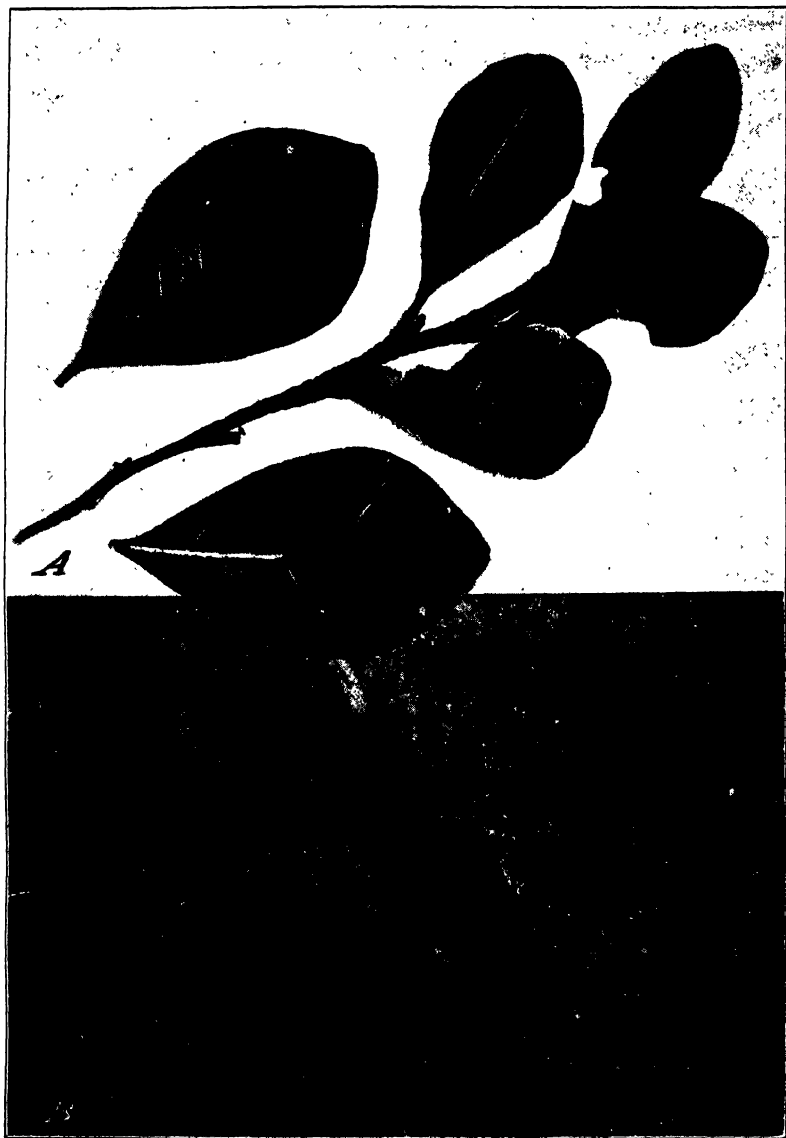


FIG. 1. *Phacidium nigrum* Cooke.

splitting in stellate clefts to expose the olive-gray, pruinose hymenium; asci clavate, gradually attenuated toward the base, broadly rounded at the apex,  $120-130 \times 13-18 \mu$ ; ascospores obliquely uniseriate below, irregularly 2-3-seriate above, unicellular, hyaline,

ellipsoid-clavate or ellipsoid-fusoid, sometimes slightly curved, at first surrounded by a hyaline gelatinous envelope,  $26.5\text{--}30 \times 4\text{--}6 \mu$ ; paraphyses numerous, hyaline, filiform, unbranched, longer than the asci, not enlarged at the apex,  $1\text{--}1.5 \mu$  diam.; hypothecium pale brown,  $20 \mu$  thick; underlying layer hyaline, subsclerotoid,  $100\text{--}200 \mu$  thick; covering layer dense, corky, black,  $75\text{--}100 \mu$  thick, splitting in the center. No spermatogonial stage has been observed.

#### SPECIMENS EXAMINED:

Darien, Ga., 1881, H. W. Ravenel 3211, ex herb. Ellis (part of type).

San Mateo, Fla., Dec. 24, 1909, T. R. Robinson.

Florida, Dec. 1, 1920, comm. C. V. Piper.

Orlando, Fla., Feb. 19, 1938, C. L. Shear.

Winter Park, Fla., Feb. 29, 1940 and Dec. 15, 1940, C. L. Shear.

The host is given in Cooke's description and on the label of the type specimen as *Andromeda* sp., but has been determined as *Xolisma ferruginea*.

The taxonomic position of the fungus presents some difficulties. The densely crowded apothecia, developing in stromata embedded within the leaf tissue, and the presence of sterile stromata on the reverse leaf surface are more characteristic of *Rhytisma* than of *Phacidium*. No swollen cells on the lower surface of the cover, such as are described and illustrated by Nannfeldt (5, pp. 246–247, f. 37-f) and v. Hoehnel (2, p. 317, f. 15) as an opening mechanism in *Phacidium lacerum*, have been observed in *P. nigrum*. The ellipsoid-clavate or ellipsoid-fusoid spores are intermediate in length between the short ellipsoid spores of most species of *Phacidium* and the elongate spores characteristic of *Rhytisma*. Nannfeldt has pointed out (5, p. 200) that *Rhytisma* spores are not truly acicular or filiform, as they have been described by various authors, but “langgestreckt tränenförmig.”

The fungus to which *Phacidium nigrum* bears the closest resemblance is *Rhytisma Curtisii* Br. & Rav., a species on *Ilex* leaves which is the type of the genus *Macroderma* v. Hoehnel (3, p. 419) and recently referred to *Phacidium* by Luttrell (4, p. 701). In the

fungus on *Xolisma* the stromata are smaller and more densely crowded than those in *P. Curtisii*, and fruiting stromata are confined to the lower leaf surface. Both fungi resemble *Rhytisma* in the presence of the sterile stromata on the opposite surface of the leaf from the apothecia, but differ from that genus in that apothecia develop from separate stromata. In *P. nigrum* the stromata are sometimes so densely crowded that they appear to be confluent, but remain distinct, each bearing a single apothecium. The asci of *P. nigrum* are clavate and strongly narrowed toward the base, resembling those of *Rhytisma Andromedae* rather than the more cylindrical asci of *P. Curtisii*. The spores are closer to *P. Curtisii* in dimensions and form, although somewhat longer, but the clustered arrangement in two or three rows toward the top of the ascus is again more like *R. Andromedae*. It is evident that the characters discussed at some length by Nannfeldt (5, pp. 240-243) and Luttrell (4), as indicating the intermediate position of *P. Curtisii* between *Phacidium* and *Rhytisma*, hold equally true for the fungus on *Xolisma*.

Characters noted by Theissen (6, pp. 265-7, fig. 1) and v. Hoehnel (3, p. 419) as a basis for the genus *Macroderma* have been shown by Nannfeldt (5, pp. 240-241) and Luttrell (4) to be either founded on erroneous observations or on points not sufficiently stable or significant to constitute generic distinctions. *P. nigrum* is therefore not here referred to that genus.

In spite of marked resemblances to *Rhytisma*, particularly *R. Andromedae*, and the presence of characters not observed in the type of *Phacidium*, it seems advisable to leave the species, at least for the present, in the latter genus in which it was described by Cooke.

Grateful acknowledgment is made to W. Lawrence White for consulting records of the Farlow Herbarium for references to *P. nigrum*, and to Cornelius H. Muller of the Bureau of Plant Industry, for identifying and verifying the host of the specimens studied.

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## EXPLANATION OF FIGURE

FIG. 1, *A*, *Phacidium nigrum* on *Xolisma ferruginea* from Florida, showing discoloration and sterile stromata on upper leaf surface (upper detached leaf at left) and apothecia on lower surface (detached leaf below),  $\times 1\frac{1}{4}$ ; *B*, apothecia on lower surface of leaf,  $\times 10$ . (Photographic negatives by M. L. F. Foubert.)

# TYPE STUDIES ON BASIDIOMYCETES. I

R. SINGER<sup>1</sup>

## ASTROGASTRACEAE

HYDNANGIUM SODERSTROMII Lagerheim ap. Lag. & Pat. Bull. Soc. Myc. Fr. 9: 142. 1893.

A specimen belonging to the collection which was distributed by Lagerheim and collected "zwischen *Eucalyptus*-Wurzeln, Quito, Ecuador." This species is macroscopically identical with *H. carneum* growing in numerous individuals in the earth near the roots of *Eucalyptus* and *Melaleuca* in the Botanical Gardens of Europe and North America (Cambridge, Mass.; Leningrad, U. S. S. R. etc.) and generally considered to be the most typical representative of this heterogeneous genus. Spores  $14.5-15 \times 12.5-14 \mu$ , subglobose with about  $2 \mu$  long spines the tops of which are amyloid.

Conclusion: *H. Soderstromii* Lagerheim = *H. carneum* Wallr.

## BOLETACEAE

PULVEROBOLETUS RAVENELII (Berk. & Curt.) Murrill, Mycologia 1: 9. 1909. *Boletus Ravenelii* Berk. & Curt. Ann. Mag. Nat. Hist. 2: 429. 1853.

Investigable specimens of this species were carefully compared with the specimens of Curtis and of Murrill. One collection (Alabama, coll. Earle) shows the following characters: true veil present, cortinoid, composed of thin colorless filaments. The bright yellow color is due to yellow crystalline bodies. No clamp connections seen. Spores are ovoid-cylindrical or subfusoid, strongly colored (brown)  $10-12 \times 5-6 \mu$ .  $Q = 2$ ; basidia 4-spored, clavate,  $25-32 \times 11 \mu$ ; cystidia hyaline or brown, fusoid or subclavate, with a short and thin apiculus,  $36-47 \times 7-10.5 \mu$ ; trama of the tube walls of the *Xerocomus*-type, i.e., not truly bilateral.

<sup>1</sup> Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 199.

*Conclusion:* For those who prefer larger genera (like *Gyrodon* including *Boletinellus* and *Paragyrodon*) it may be recommendable to include *Boletus Ravenelii*, and perhaps the whole *Pulveroboletus*-group, as a subgenus in the genus *Xerocomus* from which it does not differ actually except for the rather peculiar veil. Those who accept genera based chiefly on the presence of a veil may prefer to recognize the genus *Pulveroboletus* Murr.

PHYLLOPORUS ROMPELII Pat. & Rick, *Brotéria* 6: 81. *pl.* 6, *fig.* 1. 1907.

I compared a well preserved specimen collected by D. H. Linder in British Guiana with originals of Rick from Rio Grande do Sul, Brazil. Both are identical in all regards. The *spores* are ellipsoid to almost reniform,  $8-9.8 \times 5-5.8 \mu$ , smooth, fairly well colored (brown); *basidia*  $26-45 \times 7.2-10 \mu$ , 4-spored, and with sterigmata  $7 \mu$  long; *cystidia* near the pore mouths fusoid, bottle-shaped or subulate, small,  $15-17 \times 4 \mu$ , neck  $2 \mu$  in diameter; *hyphae* with clamp connections.

*Conclusion:* There cannot be any doubt that *P. Rompelii* has all essential characters of the genus *Gyrodon*. As stated formerly (Rev. Myc. 3: 172. 1938) this tropical species is closely related to *Gyrodon merulioides* (Schwein.) Sing. (= *Boletinus porosus* Peck). Smaller species of the latter are undistinguishable from *G. Rompelii*.

GYROPORUS SUBALBELLUS Murrill, N. Am. Flora 9: 134. 1910.  
Type.

The *spores* are cylindrical-ellipsoid, hyaline, with rather thick walls, smooth,  $7.5-10 \times 4-5.5 \mu$  (thus larger than indicated in N. Am. Flora). The thick-walled *hyphae* of the wooly surface of the pileus and the *hyphae* of the trama are hyaline and provided with clamp-connections.

*Conclusion:* All typical species of *Gyroporus* have clamp connections, according to my investigations. Thus, *G. subalbellus* is a good *Gyroporus*, very closely related to *G. cyanescens*, from which it differs according to Murrill's description in having unchangeable context and hollow stipe.



## JUGASPORACEAE

OMPHALIA GIOVANELLAE Bres. Fung. Trid. I: 9. *pl.* 5, *fig.* 2.  
1881. Coll. and det. Bresadola, Gocciadoro pr. Trento, locis  
herbidis, July, 1899.

*Spores*  $6.5 \times 3.8 \mu$ , with some very slight longitudinal ridges, are fusoid, hyaline, with a distinct hilar depression, not amyloid; *basidia* up to  $25 \times 8.3 \mu$ ; *cystidia* none; *gill trama* somewhat intermixed; *hyphae* of the surface of the pileus  $2-6 \mu$  in diameter, all without clamp connections. The *lamellae* of the dry plant are dark, dull yellow. The carpophores grew directly on the earth. *Pileus* slightly eccentric in some specimens.

*Conclusion:* Like some other "Omphaliae" and "Pleuroti", for example *Pleurotus Passeckerianus*, recte *Clitopilus Passeckerianus* (Pilát) Jossierand, *Omphalia Giovanellae* is a typical representative of the Jugasporaceae. All species of this family seem to be homothallic (cf. Kühner et Vandendries, Rev. Cyt. et Cytophys. Veg. 2 (3): 6) and this is the reason for the absence of clamp connections in all species studied by modern authors. (I studied personally *C. variabilis* sens. Fayod, *C. Passeckerianus*, *C. mutilus* sens. Lange, *C. prunulus*.) The typical Omphaliae have no clamp connections either, as I could state for *O. umbellifera*, *philonotis* and allied species, but their spores are always smooth and white. The spore print of *C. Giovanellae* is expected to be pinkish. *C. Giovanellae* belonging to the Jugasporaceae, another question arises concerning the limits of the genera *Hexajuga* and *Octojuga*, established by Fayod. It seems to me now that Maire and Jossierand are right in uniting the smaller and the bigger forms into one genus and using for it the Friesian name *Clitopilus*. Thus *Omphalia Giovanellae* becomes: *Clitopilus Giovanellae* (Bres.) comb. nov. (*Octojuga Giovanellae* according to the older conception).

## RUSSULACEAE

RUSSULA BALLOUI Peck, Bull. N. Y. State Mus. 167: 31. 1913.  
Well prepared specimens from the type locality, September,  
1915.

*Spores*  $8.5-12 \times 7.3-9 \mu$ , asymmetrical ornamentation consisting of  $0.8-1.1 \mu$  high spines or somewhat shorter warts, type IIIa,

IIIb, sometimes VIII<sup>2</sup>; *basidia*  $34-44 \times 10-11.5 \mu$ , 4-spored with sterigmata  $5-8.7 \mu$  long; *cystidia* with a rounded top, upper part with banded contents,  $36-64 \times 8.5 \mu$ . Warts of the pileus now brown, consisting of an irregular texture of cylindrical hyphae, which are  $4-5.3 \mu$  thick, brown-yellow in  $NH_3$ , often septate or with plasma-bridges, with membrane-pigment. The next deeper stratum consists of transversally arranged normal hyphae with non or moderately thickened membranes,  $2-4.6 \mu$  thick with about  $1.7 \mu$  thick end-links having acute tops. In this part of the cutis there are laticiferae of  $4-9 \mu$  diameter. The margin is involute for a long time, subacute ( $\pm 90^\circ$ ) absolutely even, although thin. The veil fragments form a crust on the center of the pileus, and areolae towards the margin. The same fulvous brown areolae are found on the base of the stipe. Lamellae not anastomosing.

*Conclusion:* *R. Balloui* belongs to the subsection *Fistulosinae* Heim. It is distinguished by the anatomical characters of the cutis and the spore ornamentation. The analysis of the cutis by J. Schaeffer seems to be wrong or belonging to another species.

*RUSSULA INSIGNIS* Burl. N. Am. Flora 9: 212. 1915, non Quélet. (1887).

This collection is not the type but it is determined by G. S. Burlingham and fits perfectly the diagnosis. *Spores*  $7.2-10.2 (-12.5) \times 6.5-7.7 \mu$ , echinulate; *basidia*  $32 \times 12 \mu$ ; *cystidia*  $50-85 \times 4-12.8 \mu$ , with granulate or banded contents, very numerous at the edge; *epicutis* of the pileus with thin-walled, partially hyaline, partially yellowish brown, septate, subulate or clavate hairs with blunt tops,  $8-13 \mu$  in diameter.

*Conclusion:* This species has nothing to do with the somewhat dubious species of Quélet. I have therefore proposed the name *R. Burlinghamiae* Sing. Bull. Soc. Myc. Fr. 54: (2): 134. 1938. It belongs to the same group as the preceding species.

<sup>2</sup> For explanation of the figures marking the different types of spore ornamentation in *Russulac* and *Lactarii* see Beih. Bot. Centralb. 49 (2): 218-220. 1932, or Bull. Soc. Myc. Fr. 51 (2): 303-304. 1936.

RUSSULA MUSTELINA Fries sens. Bres. Icon. 9: 403. pl. 403. 1929.

The figures of *R. mustelina* given in the Iconographia were considered as rather dubious. In this connection it is interesting to note that the original material sent by Bresadola to the N. Y. Botanical Garden is *R. mustelina* Fries sens. Melzer & Zvára (*R. elephantina* Fries sens. Sing.).

RUSSULA EARLEI Peck, Bull. N. Y. State Mus. 67: 24. 1903.  
Type collection.

The spores are ellipsoid,  $5-8.5 \times 4-5.5 \mu$ , mostly  $6.8-7.5 \times 5-5.5 \mu$ , ornamentation  $0.3-0.4 \mu$  high, type VI, rarely VI-VIII, IV, hyaline in ammonia, asymmetrical truly verrucose in spite of the reduced height of the warts in iodine; cystidia of the edge  $34-50-80 \times 4.3-6.8 \mu$ , cylindrical, with few granulae in the top or in the middle part, rarely the whole upper part with content; basidia  $46 \times 7.5 \mu$ ; gill trama chiefly vesiculose with scattered normal hyphae and laticiferous vessels of  $5-10 \mu$  in diameter. The cuticle of the pileus consisting of more or less interwoven but tangential hyphae; these hyphae are rather long and  $2-7.5 \mu$  broad, and lie loosely in a mucilaginous layer. Some of them ending in hair-like bodies, which are clavate or contracted in the middle,  $3-8.5 \mu$  broad; dermatocystidia none.

*Conclusion:* This characteristic species belongs to the subsection *Elephantinae*. It has some common characters with the subsection *Foetentinae*.

RUSSULA THEISSENII Rick, Brotéria 6: 74. 1907. Specimens determined and distributed by Rick 1930 and 1931.

The spores are coarsely warted, hyaline in  $\text{NH}_3$ , asymmetrical,  $8.5-10.5 \times 7.5-8.3 \mu$ , ornamentation  $0.2-0.9 \mu$  high, type IIIa, sometimes IIIb; basidia  $35 \times 13.5 \mu$ ; cystidia  $75 \times 16.5 \mu$ . The pileus is without true dermatocystidia, but with thickened cystidia-like and often septate ends of hyphae. Surface staining brown with KOH. The villose margin is no longer evident in these specimens. Lamellae not regularly alternating. The indication of yel-

low spores in the original description may be explained by the presence in the hymenium of yellow amorphous incrustations.

*Conclusion:* This species seems to be intermediate between *Elephantinae* and *Foetentinae*.

RUSSULA VENTRICOSIPES Peck, Bull. Torrey Club 29: 70. 1902.  
Type.

Type material studied by me in the New York Botanical Garden is identical in every respect with a collection from Toms River, N. J. (Murrill, *Tricholoma equestre*) and with a rich collection of fresh material in all stages of development from Wellfleet, Mass. (D. H. Linder). The following description is a combined description of the above mentioned materials:

*Pileus* reddish in the primordia, very soon changing to pale brownish and then to brown (exactly in the colors of *Russula foetens* and its varieties), with a darker center or unicolorous, frequently with an innate fibrosity like *Russula foetens* or *pectinata*, otherwise smooth and glabrous, hemisphaerical with a shallow umbilicus which develops to an infundibuliform depression, the margin remaining convex or the whole plant becoming concave at last, 42–80 mm. broad; *margin* strongly involute, adpressed to the stipe, later more straight and becoming shortly (4–7 mm.) and tardily but decidedly and constantly sulcate, not tuberculate, acute; *cuticle* rather thick, hard and firm, very viscid when fresh and wet with needles adhering on the surface, later merely humid or almost dry, not shining or slightly to strongly so on the margin, when dry, not separable except on the outer third. In SV<sup>3</sup> only a small number of the hyphae of the cutis turn blue to black and only a few of these reaching the scarcely developed epicutis are cystidia-like, showing very scattered blue granulae and ending with a broadly rounded apex, about 4.5  $\mu$  diam. The non-reacting hyphae are about 1.5 to 4  $\mu$  thick, thin-walled (walls up to 0.5  $\mu$ ), passing through a gelatinous mass, very loosely in the epicutis and more densely and radially arranged in the subcutis, many of them undulate and not always cylindrical. Under the subcutis is a sur-

<sup>3</sup> The sulfovanillinic reagent (SV) used is that of Maire (Bull. Soc. Myc. Fr. 26: 51. 1910), but with less water. It must be freshly prepared each time the reaction is made.

prisingly abrupt line separating the cutis from the trama, the latter being non-gelatinous and showing masses of laticiferae and sphaerocystae. Therefore the cuticular part separates easily from the flesh in preparations and they first swell up strongly if previously dried. KOH: darker brown. Other reagents without effect. *Lamellae* whitish, later cream-colored, very close to crowded, brittle, narrow as in *Russula foetens* or extremely narrow (2–5 mm. broad); edge red, later concolorous or more often brown, entire, a few lamellulae present and also a few forked ones, but never regularly forked, adnexed or attenuate-free to subdecurrent. When the pileus is still closed in an early stage of development, the lamellae leave a hole between themselves and the upper part of the stipe. In this period the edge of the lamellae is fimbriate from cheilocystidia of different shapes, but mostly drawn out into a short neck or button-like appendiculus,  $50 \times 5-8 \mu$ . Their upper part is frequently wrapped in an amorphous reddish-brownish mass or incrustated by an intercellular pigment (in  $\text{NH}_3$ ), causing the red color of the edges and of the stipe. Young lamellae staining reddish brown with aniline and becoming slate grey to bluish grey around the stain. In the mature stage the same kind of cheilocystidia are seen. The *basidia* are  $40-50 \times 6.7-7.8 \mu$ , with 2 or 4 sterigmata which are  $6-8 \mu$  long; *cystidia* extremely frequent, equally on edge and sides of the lamellae,  $42-85 \times 5-8.5 \mu$ , yellow in  $\text{NH}_3$ , dark reddish brown in iodine, blackish blue in SV but rarely with banded content, not granulate, acute or obtuse, in shape like the cheilocystidia (which, however, are not pseudoamyloid); most of them do not reach the level of the sterigmata but they arise deep in the trama and thus are true pseudocystidia. The *spores* are discharged from the young closed hymenophore mostly round, later the majority of them become ellipsoid or even subcylindrical, with or without a hilar-depression (in the latter case only flat at the inner side),  $8-10 \times 4-5.5 \mu$ , in other specimens  $9-11 \times 5-7 \mu$ , in the type specimen (fully mature)  $5-9.5 \times 2.5-6.8 \mu$ , and with ornamentation  $0.1-0.2 \mu$  high, of type VI–VII, also III–VII; spore print B<sup>4</sup>; *subhymenium* vesiculose, well devel-

<sup>4</sup> The spore print color is described in accordance with the scale of Crawshaw, C. The spore ornamentation of *Russula*, London, 1930.

oped; *trama* narrow, intermixed with numerous lacticiferous vessels (about  $5-6\mu$  thick) and sphaerocysts ( $13-16\mu$  broad); normal hyphae rather frequent. *Stipe* red, "Light Jasper Red" to "Light Coral Red" (Ridgway), later the reddish color mixed up with pale brownish, and in the mature plant the red tint mostly disappearing and the whole stipe becoming concolorous, minutely granular or spotted by coarse brown granulae, but more often smooth, never pruinose, ordinarily tapering from the top to the base but sometimes more ventricose or cylindrical and attenuate only at the base, solid, later often with 1 or 2 cavities. On the surface of the stipe are many hyphae turning dark blue in SV and some of them are cystidia-like. The granulae consist of fasciculate and, except for the pigmentation, non-differentiated hyphae; they are filled by a deep ochraceous brown pigment solution and incrustated by a similar brown intercellular pigment. The mycelium, according to D. H. Linder, is reddish. *Flesh* yellowish white, later brownish white with a purer white zone between the cortex of the stipe and the inner cylinder, turning more or less brownish in old specimens, particularly in the wounded places and in the stipe; firm, rather elastic. *Odor* like the odor of *Russula foetens* but much weaker and the component of nitrobenzol almost completely lacking. *Taste* slowly but very acrid and slightly bitter, very old specimens milder. With  $\text{FeSO}_4$  the flesh becomes slowly and very faintly dirty grey but near the cortex, dirty reddish; with formaline there is no reaction; with Phenol a normal reaction to dark chocolate brown; with KOH it turns darker brown, where already brownish; with  $\text{H}_2\text{SO}_4$  a dirty greyish, and finally with aniline it changes to lemon yellow.

**HABITAT:** In pine woods on sandy soil. August–September. **Area:** Eastern part of the United States.

**Conclusion:** This species has nothing to do with *Russula pulverulenta* but it belongs to the *R. foetens*-group: *R. foetens*, *Laurocerasi*, *deremensis*, *punctipes*, *ventricosipes*. It is quite singular in having a red intercellular pigment and oblong, punctate spores. These spores would not be distinguishable from *Melanoleuca*-spores if there were no shorter ones between them. *Melanoleuca* has much more in common with *Russula* than the Hygrophoraceae.

RUSSULA VIRIDELLA Peck, Bull. N. Y. State Mus. 105: 41. 1906, non Sing. Ann. Myc. 33: 316. 1935. This collection is not the type but authentic material, collected and determined by Peck (Horicon, N. Y., July 22, 1905).

The *spores* are  $6-7 \times 5-6 \mu$ , ornamentation  $0.4 \mu$  high with a very fine network, type IIIa, VII; *basidia* scattered between very numerous, large, fusoid, acute cystidia with an appendiculus and contents, about  $85 \times 14 \mu$ . Upper layer of the cutis of the pileus consists of very numerous and conspicuous dermatocystidia of  $9-12 \mu$  diameter, among which are repent hyphae. In the subcutis, however, only repent hyphae are present. Sphaerocystae present merely in the trama.

*Conclusion:* This analysis seems to prove that my *R. viridella* from China is not identical with the original American *R. viridella* of Peck. Thus the former has to be called *R. yuennanensis* Sing. var. **pseudoviridella** Sing. nom. nov., the violet-lilac form (*R. yuennanensis* Sing. 1926 nom. nud. = *R. viridella* var. *yuennanensis* Sing. l. c., p. 317) representing the type of the Chinese species. *R. viridella* Peck is a good species closely related to *R. polycystis* Sing. All these species belong to the subsection *Virescentinae* which divides into three groups (stirpes):

- A. Areolae consisting chiefly of hairs arising from an isodiametrical basal cell. *R. virescens* (Schff.) Fries, *crustosa* sens. lato, *chlorinosma* sens. Sing., *Patouillardii* Sing.
- B. Areolae consisting chiefly of laticiferous elements. *R. viridella* Peck, *polycystis* Sing.
- C. Areolae consisting chiefly of little or non differentiated hyphae. *R. schizoderma* Pat., *septentrionalis* Sing.

RUSSULA DURA Burl. Mycologia 16: 19. 1924. "Ex-type."

The *spores* are  $8.5-10.2 \times 7-8 \mu$ ; ornamentation  $0.6-1.0 \mu$  high, type IIIa, some spores IIIb; *basidia*  $43 \times 7.7 \mu$  with sterigmata  $9.5 \mu$  long; *cystidia*  $61-80 \times 10-12 \mu$ , clavate-fusoid, very numerous, projecting  $30-35 \mu$ , with banded contents, not acute, but thinner near the top; *epicutis* of the pileus and the stipe consisting of hairlike hyphal ends of  $2.5-4.5 \mu$  diam., often thick-walled (wall

up to  $1\ \mu$ ), septate, some of them with cystidia-like contents, more often blunt on the pileus, more often acute on the stipe, arising from a subcutis of subparallel-interwoven tangential hyphae. No true dermatocystidia seen. Parts of the stipe are still beautifully light yellow.

*Conclusion:* This species is very near, perhaps too near to *R. ochroleucoides* Kauffm. Both of them form a transition between *Fistulosinae* and *Lepidinae*.

RUSSULA BLANDA Burl. N. Am. Flora 9: 213. 1915. Type.

The *spores* measure  $7-7.5 \times 6-6.3\ \mu$ , hyaline and slightly rough in  $\text{NH}_3$ , ornamentation  $0.2-0.4\ \mu$  high, type II, II-IV, IV, IIIb-VIII, warts blunt, short; *basidia* about  $25 \times 8-10\ \mu$ ; *cystidia* not found, but probably present. *Trama* consisting of sphaerocysts and normal hyphae of about  $3\ \mu$  diameter, some up to  $9\ \mu$  diameter. The ends are often hair- or cystidia-like, obtuse, cylindrical, fusoid, subulate or clavate, without contents or surface incrustation ( $\text{NH}_3$ ), rarely coarsely incrustated, often wavy-flexuose, rarely branched,  $25-53 \times 3-13\ \mu$  (primordial hyphae?). *Dermatocystidia* none. Flesh of the stipe brown with SV.

*Conclusion:* This species, found but once at the type locality, needs further observation and careful comparison with the European *R. lactea*.

RUSSULA PULCHRA Burl. Mycologia 10: 95. 1918. The specimen seems to be part of the type collection or at least from the type locality: Stow, Mass.

The *spores* are slightly yellowish in  $\text{NH}_3$ ,  $8-11 \times 6.5-9.5\ \mu$ , ornamentation consisting of long ( $1.0-1.7\ \mu$ ) spines, type mostly VI, also VI-VIII, V, IV, II-IV; *basidia*  $40-45 \times 13.5-14\ \mu$ ; *cystidia* clavate or fusoid,  $55-70 \times 9.3-12\ \mu$ , with content, showing long appendiculi, particularly the cystidia on the edge: appendiculi  $8.5-10\ \mu$  long. *Epicutis* of the pileus without dermatocystidia, with primordial hyphae and hairs of about  $12.5 \times 3.5-7.5\ \mu$ . The cuticle is faintly warty under a lens.

*Conclusion:* *R. pulchra* is probably a representative of the *Lepidinae*, but it needs chemical investigation on the fresh plant, as it



is very distinct from other *Lepidinae* and microscopically reminding of the *Xerampelinae*.

*RUSSULA PERPLEXA* Burl. Mycologia 10: 96. 1918. Apparently the type.

The *spores* are yellowish in  $\text{NH}_3$ , in mass about  $C$ ,  $9.5\text{--}10.5 \times 7.7\text{--}8.8 \mu$ , ornamentation  $0.8\text{--}1.0 \mu$  high, type IV, VI, VIII; *cystidia* with banded contents,  $52\text{--}55 \times 9.5\text{--}11 \mu$ . *Dermatocystidia* of the pileus  $85\text{--}126 \times 5.5\text{--}8.5 \mu$ , acute or rounded and among them are many hyphae transformed into hairs or primordial hyphae. The carpophores suggest macroscopically *R. badia* or *R. xerampelina*. The *stipe* is still pink and slightly brownish.

*Conclusion*: Same as for *R. pulchra*.

*RUSSULA PRAEUMBONATA* Burl. Mycologia 13: 134. 1921. "From type."

The *spores* are  $9.8\text{--}11.8 \times 6.8\text{--}9.8 \mu$ , ornamentation  $0.9\text{--}1.3 \mu$  high, type III, mostly IIIa with very fine, rarely less fine, connecting lines; *basidia*  $34\text{--}43 \times 10\text{--}12.3 \mu$ ; *cystidia*  $44\text{--}50 \times 7.3\text{--}7.5 \mu$ ; *cutis* of the pileus consisting of thin-walled septate cylindrical hyphae of  $2.5\text{--}8.5 \mu$  in diameter, and immediately under these hyphae are the sphaerocysts of the trama.

*Conclusion*: A well characterized species of the *Lilacea*-group of *Lepidinae*.

*RUSSULA SULCATIPES* Murrill, Mycologia 4: 291. pl. 76, fig. 4. 1912. Type specimen.

The *spores* are  $7.3\text{--}10.5 \times 6.7\text{--}8.5 \mu$ , ornamentation  $0.3\text{--}0.8 \mu$  high, type II-IIIa, IIIb, some IV, V, VI; *basidia*  $34\text{--}48 \times 10\text{--}11 \mu$ ; *cystidia* very numerous near the edge, rarer on the sides, without contents, fusoid, but often narrowed in the middle, with a remarkably long (up to  $20 \mu$ !) appendiculus, about  $70 \times 8.5 \mu$ ; *hyphae of the cuticle* of the pileus very long and scarcely septate, some of which are hair-like,  $4 \mu$  thick; *dermatocystidia* none. The specimens show far more greenish tints than one might assume from reading the original diagnosis and from examination of the

figures. The sulcate stipe is not very evident in the dry condition. The margin is subacute, then subobtuse.

*Conclusion:* This fungus belongs to the section of *Chlorinae*. I am inclined to think it is merely a form of *Russula Mariae*.

RUSSULA HIBBARDIAE Burl. Mycologia 13: 132. pl. 7, fig. 4.  
1921. Specimens from the type locality: Newfane Hill, Vermont.

The spores are  $6.8-9.5 \times 6.3-8.5 \mu$ , ornamentation consisting of faint granulae or spines up to  $0.8 \mu$  high, type IIIb, IV, V, some VII-IX; basidia  $37 \times 12 \mu$ ; cystidia with granular or banded contents, obtuse or acute, often appendiculate (appendiculus  $2-10 \mu$  long), those on the edge more often appendiculate or acuminate than those on the sides of the lamellae; epicutis of the pileus with hairs and primordial hyphae ( $2-7 \mu$  in diam.); dermatocystidia, none. The margin of the pileus is rather thin, not rounded. Dried specimens with greenish tints.

*Conclusion:* Like the preceding species, *R. Hibbardiae* seems to be closely related to the *R. Mariae*-group, but it is distinguishable from *R. Mariae* by the spore characters, and also macroscopically.

RUSSULA FLOCCULOSA Burl. N. Am. Flora 9: 213. 1915. Type.

Spores are  $6.8-9 \times 5.5-7.3 \mu$ , ornamentation  $0.2-0.4 \mu$  high, type IIIb, IV, exceptionally II-IV, most frequently with very fine, interrupted connecting lines; basidia  $33 \times 8.5 \mu$ , 4-spored; cystidia versiform, with a faint granular content,  $50 \times 7-8 \mu$ ; pileus without dermatocystidia, but with numerous hairs in the epicutis; from a sphaerical, irregularly rounded basal hypha (about  $11 \times 7-8.5 \mu$ ) strongly reduced at the septa, arises a long filament of  $2-6 \mu$  diameter, while some other hairs are cylindrical-multiseptate without the sphaerical basal cell.

*Conclusion:* The general appearance of the dried specimens and all microscopical data except the spore ornamentation suggest *R. vesca*. The substratum, beech leaves, is not in disaccord with this interpretation. A long cylindrical stipe and subdistant lamellae are not typical, but also not impossible for *R. vesca*. The most important difference is in the spores, which are reticulated in

*R. vesca* "forma tenuis" J. Schaeffer which, however, differs macroscopically. Further studies on the variability of these characters connected with establishing of the  $\text{FeSO}_4$  reaction may decide whether this plant is a subspecies or form of *R. vesca*, or a closely related but distinct species.

There is another closely related eastern species, *R. brunneola* Burl. N. Am. Flora 9: 233. 1915. I have not seen the type, but specimens which must have been collected near the type locality in Vermont seem to be not distinct from the European *R. vesca* f. *Romellii* Sing.

*R. vesca* has hitherto been reported twice in America (Kauffman, 1909, and McIlvaine, 1902), but these indications used to be considered as doubtful. Although I found the typical European *R. vesca* rather frequently in Maine and New Hampshire, some under *Betula* and some under *Fagus*. The reactions and the spore ornamentation are exactly the same as in the European plants. Even the color of the pileus does not differ here, and the white stipes were tapering downwards. There can be no doubt that the true *R. vesca* f. *typica* exists in North America.

#### RUSSULA GRISEA and RUSSULA CAERULEA sens. Bres.

Specimens of these species, the latter considered as a variety of *R. grisea*, collected and determined by Bresadola, are not distinct from *R. Ferreri* Sing.: Spores  $7.5-8 \times 6-6.5 \mu$ , ornamentation  $0.3-0.4 \mu$  high, type IV, also VI (VIII); cystidia with content,  $8-10 \mu$  broad. Bresadola, Iconographia, pl. 452, is therefore correctly interpreted as *R. Ferreri* in my commentary of Bresadola's *Russula*-pictures (Rev. Myc. 1: 287. 1936).

RUSSULA DAVISII Burl. Mycologia 10: 93. 1918. Specimen, collected by the author of the species, preserved at N. Y. Botanical Garden.

Spores  $9.5-14.5 \times 7-13 \mu$ , yellow in  $\text{NH}_3$ , ornamentation about  $1.6 \mu$  high, type VI; basidia  $47 \times 15 \mu$ ; cheilocystidia  $70 \times 9-10 \mu$ , acute.

Conclusion: Probably near to or identical with *R. olivacea* (Schaeff.) Fries.

RUSSULA MURRILLII Burl. Mycologia 5: 310. 1913. Type.

This plant is identical in all regards with *R. punctata* Krombholz sens. Sing. = *R. Turci* Bres. sens. Maire, Melz. & Zv. = *R. amethystina* Quél.

RUSSULA RUBRIOCHRACEA Murrill, Mycologia 4: 293. 1912. Type.

The spores are  $9.3\text{--}10.5 \times 8.5\text{--}9 \mu$ , yellow in  $\text{NH}_3$ , ornamentation  $0.4\text{--}2.2 \mu$  high, type VI, sometimes IV, V; basidia  $23\text{--}43 \times 10\text{--}16.2 \mu$ , usually  $35\text{--}43 \times 11\text{--}15 \mu$ ; cystidia  $56\text{--}85 \times 7.7\text{--}11 \mu$ , numerous, with banded content, often with appendiculus ( $3.5\text{--}8 \mu$  long); dermatocystidia of the pileus moderately numerous,  $6\text{--}8 \mu$  thick. Some of the  $1.5\text{--}3.3 \mu$  thick normal hyphae are transformed into fusoid, acute, empty bodies (hairs) of  $6 \mu$  diameter in the epicutis.

Conclusion: If *R. rubriochracea* is not one of the acrid forms of *R. xerampelina*—the specimens look like *R. xerampelina* var. *rubra*—then it is a good species of the *Rubrinae*, well distinguished from *R. Mariae* by the spore ornamentation, from *R. rubra* by the red stipe and from *R. badia* by the less reticulate spores.

RUSSULA MORDAX Burl. Mycologia 28: 259. 1936. Type.

Spores  $7.7\text{--}10.2 \times 6\text{--}8.5 \mu$ , ornamentation about  $0.9 \mu$  high, type IIIa, some IIIb; basidia about  $50 \times 10\text{--}10.5 \mu$ ; cystidia  $50\text{--}60 \times 6.6\text{--}10 \mu$ , rather numerous, with banded contents, versiform; dermatocystidia numerous. The color of the spores in mass must be at least E (stated by comparison).

Conclusion: The macroscopical appearance and the above indicated micro-characters prove that the type of *R. mordax* belongs to *R. badia* Quél. The differences indicated by G. S. Burlingham (l. c.) are not important enough for separating a variety. The consequence is that an actually new species described by me as *R. ? mordax* Burl. vel sp. nov. (Bull. Soc. Myc. Fr. 54 (2): 144. 1938) is not *R. mordax*. I therefore propose for it the new name *R. chrysodacryoides* Sing. nom. nov.

RUSSULA SERISSIMA Peck, Bull. N. Y. State Mus. 139: 44. 1910.

Apparently the type, which was collected by Blackford, and is preserved at the Farlow Herbarium.

*Spores*  $10.5\text{--}13.3 \times 8.7\text{--}10.5 \mu$ , ornamentations  $0.8\text{--}1.2 \mu$  high, type VI, sometimes IV, V; *basidia*  $40 \times 12 \mu$ . In the *epicutis* of the pileus are numerous hairs and very scattered dermatocystidia, which are rounded above and show some content; they measure about  $75 \times 12 \mu$ .

*Conclusion:* This species does not belong to the *Decolorantinae* nor is it related to *R. serissima* Kauffm. (Herb.) which has reticulate spores. Peck says: "Not changing to brown where wounded," but it is apparent that the type belongs to *R. xerampelina*. Actually *R. xerampelina* (under the name of *R. atropurpurea* Peck) is cited in North American Flora in the same section (*Atropurpureae*) and differs, according to the key, chiefly in the different tinge of the wounds. Hence, the whole section of the *Atropurpureae* disappears, as both species are only forms of *R. xerampelina*.

RUSSULA BARLAE Quél. sens. Mass. Bot. Trans. Yorksh. Nat. Un.

4: 132. 1905. Specimen, collected by Massee, sent from the Kew Herbarium to N. Y. Botanical Garden.

These specimens do not seem to be *R. xerampelina* var. *Barlae* sens. Sing., Melz. & Zv., J. Schaeffer, although a note, found in the same cover, indicates that the plate of Cooke (apparently *Pl. 1061*–*1040*) is painted from this same specimen. Thus it will be preferable to omit the name of Massee and Cooke when *R. xerampelina* var. *Barlae* is cited and to write merely: var. *Barlae* Melz. & Zv. This combination is possible because Massee, British Fung. Flora III: 62. 1893, related his *Barlae* to his *vesca*, not to *xerampelina*; later he mentions it as a distinct species.

RUSSULA CINERASCENS Beardslee, Jour. Elisha Mitchell Sci. Soc.

33 (4): 164, 1918.

Beardslee's specimens from North Carolina have *spores* of  $7.7\text{--}9 \times 7\text{--}7.7 \mu$  with a very low ornamentation (about  $0.3 \mu$ ) of type IIIa, II–VII; *cystidia*  $62\text{--}77 \times 8\text{--}11.5 \mu$  with banded contents all

over or only in a part of the cystidium, very crowded on the edge of the lamellae which is heteromorphous; the *cystidia* are versiform, usually larger at the upper third and often appendiculate ( $2\ \mu$  and more); *dermatocystidia* are present.

*Conclusion:* This is a good species of the subsection *Decolorantinae* distinguished from *R. decolorans* by the short ornamentation of the spores. See also the next species.

RUSSULA BURKEI Burl. Mycologia 16: 21. 1924. Type.

Spore print about C-D. *Spores*  $8.5-9 \times 7.5-8\ \mu$ , ornamentations about  $0.3\ \mu$ , type IIIa; *basidia*  $30-40 \times 9-12\ \mu$ ; *cystidia* numerous,  $55-66 \times 8-10\ \mu$ , versiform, often clavate or fusoid, with banded contents; *dermatocystidia* of the epicutis of the pileus clavate,  $27-42 \times 5-6\ \mu$ . The dried specimens showed more reddish tints than indicated in the diagnosis.

*Conclusion:* The micro-characters of this and the preceding species are almost the same and the only differences are the taste and the odor. Although I found fresh material of the acrid form without any odor comparable to the odor of *Russula foetens*, I am inclined to believe that *R. Burkei* is only the acrid variety of *R. cinerascens*, as *R. variata* is the acrid variety of *R. cyanoxantha*. But Dr. Gertrude S. Burlingham, to whom I addressed myself in this matter, answered me: "I would say that these two are distinct. . . . I find that while the two have similar markings, the spores of *R. cinerascens* are more nearly globular and that the protuberances are smaller and that there are more connecting lines in the spores of *Russula Burkei*." Description of fresh material of *R. Burkei*:

*Pileus* with pink reddish spots on cream pale ground (like Britzelmayr's pictures of *Russula Britzelmayri*), often with rusty brownish small spots in the center (like *Russula maculata*), at last fading, convex or campanulate-convex, becoming almost flat and usually depressed in the center, 75 mm. broad; *cuticle* separable about halfway to the center, shining when dried, glabrous, viscid when moist, margin subacute, later obtuse and rounded, even or very shortly striate-undulate; *dermatocystidia* numerous, blue in SV; *lamellae* whitish yellow, later cream-colored and at last the same color as in *Russula decolorans* (perhaps a little paler), equal,

few or none forking but with ground-anastomoses, broadest in the outer third, rather broad (about 10 mm.), rounded-free or narrowed-free, crowded; *spore print* nearly D; *spores*  $8.5-9 \times 7.5-8 \mu$ , ornamentations  $0.2-0.3 \mu$  high, type IIIa, VII; *cystidia*  $50 \times 7.8-13 \mu$ , usually acute, with banded contents, blue in SV, numerous; *stipe* white, greyish where handled, often rusty brownish at the very base, smooth, slightly ridged, solid or stuffed, firm, up to  $80 \times 32$  mm., tapering upwards; *dermatocystidia* numerous; *flesh* white, reddening, then greyish black where wounded, greyish or blackish in old and in dried specimens, firm, thick; *taste* becomes slowly very acrid. The *odor* is faint, fruity, not recalling *Russula foetens* nor *Russula maculata*. Formaline: quick reddish reaction.

HABITAT: Mixed woods (*Fagus*, *Pinus*, *Tsuga*, *Acer*), Chocorua, N. H., July 26, 1941, coll. D. H. Linder & R. Singer.

RUSSULA MAGNA Beardslee, Jour. Elisha Mitchell Sci. Soc. 33: 183. 1918.

Beardslee's specimens from Asheville, N. C., preserved at N. Y. Botanical Garden, have now an agreeable particular odor like fresh hard-wood timber. The spores are evidently yellowish (at least C or D). The *lamellae* are broad, moderately crowded, anastomosing, equal; *spores*  $9.5-11 \times 8-9.5 \mu$ , subglobose, but asymmetrical with a lemon-yellow shine in  $\text{NH}_3$ , the ornamentations  $0.3 \mu$ , very evident and densely reticulate: II-IIIa-VII, but some are also IV-V; *basidia*  $42-43 \times 9-14 \mu$ , 4-spored; *cystidia*  $65-100 \times 8.8-10 \mu$ , rather numerous on the sides and exceedingly numerous on the edges of the lamellae, often with banded contents in the middle part, but more often granulate, sometimes septate, versiform, usually more or less fusoid, or occasionally narrowed in the middle part, with an extremely long appendiculus ( $26-27.2 \times 2 \mu$ ); *epicutis* of the pileus with broad clavate hyphae  $4-4.5 \mu$  in diameter or with cylindrical hyphae that are  $4 \mu$  in diameter, hyaline or with a brownish tinge, always with rounded ends; *dermatocystidia* clavate with banded contents,  $55-95 \times 5.5-6 \mu$ , rather scattered.

*Conclusion:* An exceptionally well characterized species of the *Decolorantinae* where the plant was placed in my monograph. J. Schaeffer put it into the *Nigricantinae* emphasizing that "this mush-

room belongs in the neighborhood of *R. nigricans* also according to the author." This statement is wrong. Beardslee, the author of the species, writes absolutely correctly: "The dried specimens would probably be taken for *R. nigricans* but it is amply distinct from this species. The yellow spores, nearly equal gills and strong odor, at once distinguish it." And Coker: "It is most nearly related to *xerampelina*" (thus the *Decolorantes*).

*RUSSULA CONSOBRINA* Fries, Obs. Myc. 2: 195. 1818 [*Agaricus* (*Russula*)].

As far as I know there is no type of *Russula consobrina* left by Fries. But it is known that a *Russula* as described below is found in "abiegnis" (*Piceetum excelsae*) of Scandinavia and that Karsten who gave a good description of this species and had a large exchange of exsiccata with Fries quoted *R. consobrina* as being found "in silvis abiegnis Fenniae australis passim" (Myc. Fenn. Bidr. Kaenned. Finl. Nat. Folk, Helsingfors, p. 220. 1876). Therefore I searched for some years in the spruce woods of Southern Finland from Helsingfors to the Russian frontier and found that there was only one species comparable to *R. consobrina* which is really not frequent except in the years when *Boletus edulis* is growing abundantly. The following description is the result of my studies on fresh Finnish material and can be considered as covering Karsten's *consobrina* and most probably Fries'. *R. consobrina* var. *rufescens* J. Schaeffer is also identical: *Pileus* umbra, grey brown, paler at the margin, later avellaneous or more rarely greyish pale all over, venose like *Russula vesca*, especially in the center but the veins are "innate" (they do not project but very slightly), otherwise smooth and glabrous, convex and usually umbilicate, later convex with the center depressed, at last infundibuliform, 50–100 mm. broad, exceptionally broader or smaller; *margin* even, only at last not very evidently and not constantly shortly striate-tuberculate, never fibrous, acute to subobtuse, later acute to obtuse, but never rounded. Cuticle separable four-fifths of the radius from the margin towards the center, viscid, quickly drying; *epicutis* consisting of more or less erect non-septate hairs, hyaline above and



brownish colored below, subacute to obtuse, usually with an enlarged base,  $1.5-3\ \mu$  thick. Between them are found some rather scattered, versiform dermatocystidia which are  $33-100 \times 6.5-8\ \mu$ ; *subcutis* with horizontal, normal hyphae of  $2.5\ \mu$  and more in diameter. Many hairs and hyphae, although morphologically not distinct from the others, are actually lacticiferous bodies and turn blue in SV. The KOH reaction is slow and faint, the tissue becoming only a little darker; *lamellae* cream white, later pale cream, rather broad (8 mm. in large specimens), mostly simple near the stipe, but intermixed with numerous lamellulae or forked lamellae or with both, anastomosing at the base, decidedly not ventricose, narrowed from the middle of the radius of the pileus or from the outer third towards the stipe and narrowed or rounded behind or almost free to free, crowded or rather crowded; *stipe* white, at last usually with a greyish network or with grey spots, often reddening by pressure, rigid, firm, later often becoming fragile, versiform but usually ventricose, solid, later with smooth cavities or stuffed,  $65-125 \times 20-30$  mm., rarely smaller; *dermatocystidia* clavate,  $5-6\ \mu$  broad; *flesh* white, greyish immediately under the cuticle and greyish also in the old stipes or along the circumference, turning reddish when wounded, but only when the proportion of water is a little under normal (in wet woods there may be no reddening at all), rigid, later more or less fragile, with exceedingly numerous lacticiferac; *taste* slowly to rather quickly becoming very acrid. Odor none, or like that of fresh apples. Formaline: quickly reddening.  $\text{FeSO}_4$ : grey. Aniline: incarnate brownish and brownish-flesh color around the stain, becoming brownish-red at last.  $\alpha$ -naphthol: exceptionally slow and slight reaction.

**HABITAT:** In dense woods of *Picea excelsa*, usually together with *Boletus edulis*. July to the end of September.

**Conclusion:** This is not the species I described as *R. consobrina* 1926 and 1932. It seems that *R. consobrina* Sing. is a variety of the fungus described by Fries and me under the name of *R. consobrina* var. *sororia*. The true *R. consobrina* as described here belongs rather to the *Decolorantinae* than to the *Foetentinae*, because of the formaline reaction and many other characters.

RUSSULA VINACEA Burl. N. Am. Flora 9: 217. 1915. "No. 87, same as 85-86" Burl. (85 is the type).

*Spores*  $9.4-10.6 \times 8-9.4 \mu$ , the ornamentations rather high and similar to that of *Russula emetica euemetica*, type IIIa; *basidia*  $44 \times 9.5-12 \mu$ , 4-spored; the *sterigmata*  $7 \mu$  long; *cystidia* versiform,  $43 \times 8.5 \mu$  and more; *dermatocystidia* rather numerous. General appearance of *Russula atropurpurea*.

*Conclusion*: A good species of the *Atropurpurea*-group, especially near to var. *atropurpurina*, which I first placed as a subspecies next to *R. emetica* because of the long spines of the spores. The type of this European form is lost, so I abandoned this form temporarily. I found the American species near Boston (Purgatory Swamp, Mass.). This enabled me to give a complete description of it:

*Pileus* "deep purplish vinaceous" (R), "carmin" (R̄), often in some places fading to "Rose dorée" (R), center usually carmine-blackish or blackish-purple and often rugose, sometimes with small pale or olivaceous spots and finally often brownish or yellowish near the center which is convex and then depressed or finally concave, 55-110 mm. broad, cuticle separable, a third or a half from the margin, not shining when dry, but smooth and viscid when moist; the margin often sublobate, subacute in specimens with close lamellae and obtuse or rounded in the ordinary ones, even or slightly striate-tuberculate when mature; *epicutis* with numerous  $4-6 \mu$  thick dermatocystidia (but less than in *R. emetica*). *Hyphae* of the subcutis  $1.5-6.5 \mu$  thick; *lamellae* white, often rusty brown where eaten by animals or where broken, close to distant, equal or more often with a few lamellulae, forking or rarely all simple, tapering-free or slightly sinuate-adnexed, strongly anastomosing, moderately broad; *spore print* almost white: more pale than B, but tone of D, between "Cartridge buff" (R) and white; *spores*  $8.5-10.5 \times 7.7-9.5 \mu$ , ornamentations  $1.0-1.3 \mu$  high, type IIIa; *basidia*  $26-44 \times 9.5-12 \mu$ ; *cystidia* versiform, numerous, blue in SV,  $43-70 \times 7-8.5(-11.7) \mu$ . Aniline: chrome yellow with yellow greenish margin around the stain, later chrome orange with a sea green margin; stipe white, often partially rusty brownish, slightly rugulose firm, later spongy stuffed or staying hard and solid, most often tapering from the base upward, less often nearly equal, 30-70

$\times 15\text{--}30$  mm.; *dermatocystidia* numerous; *flesh* white, sometimes reddish under the cuticle, usually brown where eaten by animals, firm, finally often fragile. The *taste* is very acrid; *odor* none or almost none.  $\text{FeSO}_4$ : greyish pink. Phenol: reddish, soon turning to chocolate brown.

**HABITAT:** In woods. All my collections were made under *Tsuga*. Kauffman and Burt<sup>5</sup> indicate it under *Pinus*. July (apparently until October).

**RUSSULA CRENULATA** Burl. *Mycologia* 5: 310. 1913. Type.

The *spores* are  $11.5 \times 9.5$   $\mu$ , ornamentations rather high and with very faint reticulations, IIIa, IIIb; *basidia*  $33\text{--}38 \times 8\text{--}12$   $\mu$ ; *cystidia* numerous, versiform,  $63\text{--}110 \times 8\text{--}12$   $\mu$ , the appendiculus, when present,  $2\text{--}12$   $\mu$  long; *dermatocystidia* abundant.

**Conclusion:** The type of *R. crenulata* being identical with the plant so determined by Kauffman, I can repeat my statement on this latter in a more general way: "*R. crenulata* Burl. is not (as assumed by J. Schaeffer) a form of *R. fragilis* but it is *R. eucnemetica* f. *alba*" (cf. Bull. Soc. Myc. Fr. 55: 261. 1939).

**RUSSULA REDOLENS** Burl. *Mycologia* 13: 133. 1921. "No. 15—1917. Paler green than No. 77—1916" (the latter is the type).

The *spores* are  $7.7\text{--}9 \times 6.5\text{--}7.7$   $\mu$ , ornamentations  $0.3\text{--}0.9$   $\mu$  high, type VI; *basidia*  $43 \times 8\text{--}9.5$   $\mu$ ; *cystidia*  $66\text{--}68 \times 7.5\text{--}15$   $\mu$ , often bottle shaped, acute or obtuse, often appendiculate, with banded contents.

**Conclusion:** A very striking species, not comparable with others known to me. It is difficult to put it in the right section unless more complete information about the exact spore color and about the chemical reactions is available.

**RUSSULA CAVIPES** Melzer & Zvára, *Archiv Přírodověd. Vyzkum Čech.* 17 (4): 108. 1927. non Britz.

The specimen kindly sent me in 1939 by V. Melzer as a typical one is *R. fallax* (Fries) Sacc. (sens. Singer, J. Schaeffer) in every

<sup>5</sup> Under the name *Russula atropurpurea*. *R. atropurpurea* Kauffm. and Burt-Farlow is *R. vinacea*; *R. atropurpurea* Peck, Burl. is *R. xerampelina*.

regard. This plant is frequent under fir in Europe, northern Asia, and is met with also in America.

*RUSSULA MEXICANA* Burl. *Mycologia* 3: 26. 1911. Type.

*Spores*  $7.5\text{--}9.5 \times 6.7\text{--}7.7 \mu$ , asymmetrical, ornamentations  $0.4\text{--}1.1 \mu$ , type IV, V, VI; *basidia*  $35 \times 18 \mu$ , only on the sides of the lamellae; *cystidia* extremely abundant,  $58\text{--}120 \times 8.5\text{--}18.7 \mu$ , fusoid, acute or subacute, with banded content. The edges of the lamellae are sterile, formed exclusively by cystidia. *Epicutis* of the pileus possesses a pigment which becomes intensely pink in  $\text{NH}_3$ . *Dermatocystidia* versiform, very numerous, often yellowish, sometimes appendiculate,  $2\text{--}8 \mu$  thick. The stipe possesses abundant dermatocystidia. The base of the stipe is connected with leaves. The *pileus* is bright and intensely cinnabar red. Yellow stains on the younger specimens are very evident.

*Conclusion:* This is typical *R. luteotacta* Rea and therefore *R. mexicana* is a synonym of this species.

*RUSSULA ROBINSONIAE* Burl. *N. Am. Flora* 9: 221. 1915. Type.

*Spores*  $9.2\text{--}9.5 \times 7.2\text{--}7.7 \mu$ , ornamentations up to  $0.9 \mu$  high, type II–VII (short ridges scarcely anastomosing one with another), but under a high magnification it becomes evident that these thick veins or warts are connected by extremely fine lines which form a broken or complete network (IIIa–IIIb); *basidia*  $25\text{--}32 \times 6.5\text{--}11.5 \mu$ ; *cystidia* abundant,  $58\text{--}68 \times 5.8\text{--}14.5 \mu$ , clavate or fusoid, acute or rounded, with banded content, often appendiculate; *dermatocystidia* very abundant.

*Conclusion:* This species is macroscopically like *R. Quicletii* or *helodes* but the lamellae are very narrow and close, the cuticle is opaque, the margin thin, acute, even. There are no deep yellow stains. The fungus is associated with *Picea*. *R. Robinsoniae* comes next to the European *R. helodes*, an extremely rare species, met with only in two places every year: one near Tabor in Czechoslovakia, the other near Kazan in Russia. There are, however, some minor differences between the American and European species: (1) Spores and basidia are a little smaller in the American plant and the ornamentation is less regularly reticulate; (2) The

lamellae are anastomosing; (3) The pileus is not lobate as in the European species. Both belong to the *Sardoninae*.

*RUSSULA GRACILIS* Burl. N. Am. Flora 9: 222. 1915. "Ex-type."

*Spores*  $8.5-10 \times 7.5-8.5 \mu$ , ornamentation  $0.4-0.9 \mu$  high, type IV, VI. Hymenium not fit for investigation.

*Conclusion:* Those macroscopical characters that still remain visible in the specimen and spore characters prove that the American subspecies is very near to the European one: *Spores* of the subsp. *gracillima*, as found in the region of Moscow, U. S. S. R., are  $10-11 \times 7.5-8.5 \mu$ , when fully mature, but  $8.5-11 \times 6.5-8.5 \mu$  on the lamellae; ornamentation  $0.4-1.0 \mu$  high, type IV, VI. This European subspecies is nearer to the American type than the Altaian subspecies with more connected short spore warts (cf. Bull. Soc. Myc. Fr. 54 (2): 143. 1938).

*RUSSULA HUMIDICOLA* Burl. N. Am. Flora 9: 230. 1915. Type.

*Spores*  $8-9.8 \times 7-8.5 \mu$ , ornamentation not extremely dense,  $0.6-0.9 \mu$  high, type IIIb, IV, some spores V, some rare spores VI; *basidia* measure  $32-34 \times 10.5-13 \mu$ ; *cystidia* with banded content, clavate-fusoid,  $43-68 \times 5-10 \mu$ , rather numerous; *epicutis* of the pileus with long hyphae, many of them apparently lacticiferous because of a loose content, or even cystidia-like and then cylindrical-subfusoid or fusoid, about  $70 \times 4.5-7.8 \mu$ , others hair-like and blunt-ending,  $2-3.5 \mu$  in diameter.

*Conclusion:* When I found in the Purgatory Swamp, Mass., a species which has the same appearance as the type specimens and the same characters as given in the original description and in the preceding microscopical description, I was able to complete the data about *R. humidicola* sufficiently for deciding its taxonomic position. *R. humidicola* reminds one of the *Puellarinae* because of its habits, dermatocystidia and pale spore print, but its real affinities seem to be in the *Integrinae* group. There is a good plate in the collection of unpublished pictures by Krieger at the Farlow Herbarium. Full description of fresh material:

*Pileus* "carrot red" to "light carrot red" (R) with the center "morocco red" (R) in young specimens and concolorous in older ones, paler forms "oricut pink" to "orange pink" (R) with the center "carnelian red" (R) and the margin pale or "sea-shell pink" (R) with the center more dirty and the margin white; often slightly umbonate in young plants, later flat or more often convex with a depressed center, at last cup-shaped; 38–70 mm., mostly under 50 mm.; margin soon striate-tuberculate over a large zone, obtuse-rounded; the *cuticle* viscid, later subviscid and drying quickly, two thirds of the radius or entirely separable, not shining when dry. *Epicutis* with rather scattered dermatocystidia which are laticiferae-like in many cases and about 5–6.5  $\mu$  thick; *lamellae* white, later cream-colored, broad (4–13 mm.), rather distant to rather crowded, sinuate or rounded-free, anastomosing on the ground, equal, some forking or all simple; *spore print* between C and D; *spores* 8–10.5  $\times$  7–9  $\mu$ , ornamentations 0.6–1.3, mostly 0.9  $\mu$  high, type IV, VI, but many of the spores have a very faint network of thin lines: III a–b; *basidia* 20–26  $\times$  8–10.5  $\mu$ ; *cystidia* 26–40  $\times$  6.5–10  $\mu$ , clavate, bottle shaped or fusoid, moderately numerous, with scattered or dense coarse granulae, blue in SV in the upper half; *stipe* white, stuffed to hollow, extremely fragile, cylindrical or tapering from the base upward, slightly rugulose, glabrous, 25–70  $\times$  6–14 mm.; *flesh* white under the cuticle, fragile; *taste* slightly but distinctly acrid when tested with larger quantities of young specimens, and simultaneously slightly bitterish in most cases; *odor*, none.  $\text{FeSO}_4$ : salmon to pale salmon pink. SV: dirty violet.

**HABITAT:** Under *Quercus* in woods and at the margin of the wood, mostly on the soil, one specimen on decayed wood. July.

**Observations:** A very closely related species, with almost the same microcharacters but less fragile, shorter and firmer and with pileus more pink-red and pruinose, is very common in June in Van Cortland Park, N. Y.

**RUSSULA DISPARILIS** Burl. *Mycologia* 10: 94. 1918. Type.

*Spores* 7.7–9.5  $\times$  6.7–7.7  $\mu$ , yellowish in  $\text{NH}_3$ , ornamentations consisting of cylindrical or conical spines, 0.7–1.0  $\mu$  high, type IV,

V, VI; *basidia*  $31-47 \times 9.5-15 \mu$ ; *cystidia*  $50-68 \times 8.5-9.5 \mu$  fusoid, sometimes in the central or in the upper part, with banded, but often very scattered contents, moderately numerous, a little more numerous at the edge, often, especially at the edge, appendiculate (appendiculus very long  $2.5-20 \times 2 \mu$ ); *epicutis* of the pileus with hyphae-ends about  $20 \mu$  long and  $4.5-6.5 \mu$  broad; some of them more or less cystidia-like with a few scattered granulae inside; the *pileus* is not shining and glabrous. If one does not know the description, one is inclined to range the specimens near *R. olivascens* Pers.

*Conclusion:* Further information is needed as to the exact color of the spore print and the SV-reactions. However, it can be said already that I was apparently wrong in relating this species to the *Ingratae*. It does not belong to this group.

RUSSULA FULVESCENS Burl. N. Am. Flora 9: 229. 1915. Type.

*Spores*  $8.5-12.8 \times 7.3-10.2 \mu$ , ornamentation about  $0.7 \mu$  high, type VI, some spores V or IV; *cystidia*  $58-85 \times 10.5 \mu$ , fusoid. Hyphal-ends of the *epicutis* of the pileus hair-like, some resembling primordial hyphae, or narrow cystidia.

*Conclusion:* Further information is needed as to the exact color of the spore print and the SV-reactions.

RUSSULA MAXIMA Burl. N. Am. Flora 9: 229. 1915. Type.

*Spores*  $10.8-13.5 \times 9-10.8 \mu$ , yellow in  $NH_3$ , ornamentation type IIIa; *epicutis* and elements of the hymenium exactly like my recent description of Kauffman's material of this species (cf. Bull. Soc. Myc. Fr. 54: 148. 1938 and ibid. 55: 268. 1939).

*Conclusion:* The type is the same species as that determined as *R. maxima* by me formerly. It is a good species of the *Integrinae*.

RUSSULA RUBROINCTA (Peck) Burl. N. Am. Flora 9: 229. 1915.

Coll. Morris in the Adirondacks, det. G. S. Burlingham.

This plant is exactly the European *R. paludosa* in all regards. Miss Burlingham writes in Mycologia 10: 95-96. 1918: "I have several specimens of *R. elatior* Lindb. which Professor Romell sent

me . . . *Russula elatior* has very much the same appearance as our *Russula rubrotincta*. In fact specimens of this which I sent to Professor Romell he thought must be that species and suggested to me that I be sure that young specimens of that plant, which I had sent him were not acrid. During the following season I tasted these in all stages and found the taste in all cases to be sweet and nutty. . . ." *R. elatior* is a synonym of *R. paludosa* and marks the northern race which I found to be decidedly acrid in the majority of the young specimens, but specimens of the Central-European race are quite mild as a rule and only sometimes big parts of the young hymenium give a slight feeling of acidity. The American plant belongs evidently to this latter form and so does the form collected by me at the type locality in Bavaria. *R. paludosa* is found in America under the same conditions as in Europe: *Sphagnum*-swamps with *Pinus* or *Picea*. Area: New England (Burl., Sing.: Maine; Popham Beach), New York (Peck, Burl., Kauffm.), Canada (coll. D. H. Linder, det. Singer).

RUSSULA INTEGRATA var. AURANTIACA J. Schaeffer, Ann. Myc. 31: 404. 1933. Small samples sent by J. Schaeffer to the Farlow Herbarium and to the Naturhistorisches Museum, Vienna.

*Spores*  $8.3\text{--}10.8 \times 7\text{--}9 \mu$ , ornamentation  $0.6\text{--}1.0 \mu$  high, type IV, V, VI; *basidia*  $42 \times 9 \mu$ ; *cystidia* numerous, about  $50 \times 8\text{--}10 \mu$  with banded contents; *epicutis* of the pileus with dermatocystidia  $40\text{--}60 \times 4\text{--}5 \mu$ . The spore print of the Farlow specimen equals E-F, not H.

*Conclusion*: I do not think that this is different from *R. Font-Queri* Sing. The spore color "H" indicated by J. Schaeffer may be an exception or simply an error.

RUSSULA BLACKFORDAE Peck, Bull. N. Y. State Mus. 139: 43. 1910. Type.

*Spores*  $9.5 \times 8 \mu$ , ornamentation  $0.6\text{--}1.3 \mu$  high, type IV, IIIB, IV-VIII with thin and thick connecting lines; *spore print* exactly E; *cystidia* rather numerous, with banded contents; *epicutis* of the pileus with dermatocystidia,  $45 \times 5.5\text{--}7.3 \mu$ , with scattered contents.



*Conclusion:* It is rather difficult to guess about the position of *R. Blackfordae* before the reactions are known. It seems to be similar to *R. abietina*, *R. serotina*, and to certain aberrant Asian forms of *R. sphagnophila*. It has nothing to do with *R. puellaris* because of the darker spores.

RUSSULA SPHAGNOPHILA Kauffm. Rep. Mich. Acad. Sci. 11: 86. 1906. Type.

*Spores*  $8.5-11 \times 7.7-9 \mu$ , ornamentation  $0.8-1.3 \mu$  high, type mostly IV-V, also VI, IIIb, IV-II, sometimes IIIa, II-IV-VIII, II-IIIb-VIII, the connecting lines very thin, in other spores rather coarse, straight; *basidia*  $28-38 \times 8.5-10.8 \mu$ ; *cystidia* versiform  $43-68 \times 8.5-11.5 \mu$ , rarely obtuse, more often with a long appendiculus; *dermatocystidia* on the pileus numerous,  $25-85 \times 2.5-6.8 \mu$ , versiform, mostly rounded at the top; *pileus* 15 mm. broad in dry condition and with the color of the dark purple forms most frequently met with in Europe; *margin* obtuse, striate-tuberculate; *stipe*  $32 \times 4$  mm. in the dried specimen, almost entirely red. Kauffman wrote on the label of this part of the type: "Small specimen"; thus the species is usually larger.<sup>6</sup>

*Conclusion:* The revision of the type destroys the myth of the allegedly small spores of this species (J. Schaeffer:  $7-9 \times 7-8 \mu$ , never larger, warts mostly short,  $\frac{1}{2} \mu$  "in the American" and "most frequently  $9-11 \times 8-9 \mu$  with  $\frac{1}{2}-1 \mu$  long . . . spines" in the European form. It is interesting that my measurements of the type agree perfectly with J. Schaeffer's measurements of the European form). There can be no doubt any more that the European and the American forms belong to one and the same species. *R. venosa* Velen. 1921 hardly belongs to this species, but *R. betulina* Melzer, non Burl. does. *R. sphagnophila* belongs to the subsection *Puellarinae*.

RUSSULA SUBOLIVASCENS Burl. N. Am. Flora 9: 223. 1915.

This is not a new species but a nomen novum for *Agaricus olivascens* Secr. *A. Russ. olivascens* Secr. is the same as *Russula olivascens* Pers. and therefore *R. subolivascens* becomes a synonym

<sup>6</sup> Nevertheless I found still smaller fruit bodies in the European form.

of *R. olivascens* Pers. In N. Y. Botanical Garden is a good specimen of *R. olivascens* Pers. (coll. Bres. & Murr. in southern Tyrol), there labeled *R. subolivascens*. I do not know whether or not *R. olivascens* Pers. really exists in this country, but what often is called *R. olivascens* or *subolivascens* in American collections belongs to a group of doubtful forms that I described in 1939 (see Bull. Soc. Myc. Fr. 55: 266-268. 1939).

RUSSULA TURCI Bres. Fung. Trid. 1: 22. 1882. Coll. by Bresadola at Mendola and determined by him in August 1900, preserved at the N. Y. Botanical Garden.

*Spores*  $9.5-12 \times 7-9.5 \mu$ , ornamentation  $1-1.3 \mu$  high, IV, V, VI; *hymenium* largely destroyed but single cystidia with a half or two-thirds-banded contents were observed; *dermatocystidia* of the pileus doubtful as they no longer react with SV.

*Conclusion*: I am not absolutely sure that this plant belongs to *R. abietina* Peck or to the species called by J. Schaeffer *R. chamaeleontina* or to anything else, but it is evident that it is not *R. punctata*. So far as I know, Bresadola did not mark a type among any of his numerous dried specimens. As it is decidedly not true that all exsiccatae belong to *R. punctata*, it would be more convenient to consider it as a nomen dubium.

RUSSULA BETULINA Burl. N. Am. Flora 9: 227. 1915. Type.

*Spores*  $9.5-13.5 \times 8.5-11 \mu$ , ornamentation  $1-2 \mu$  long, mostly  $1.5 \mu$ , type VI; *basidia*  $39-55 \times 10.5-16 \mu$ ; *cystidia*  $54-90 \times 7-10 \mu$ , numerous, acute or obtuse, with banded contents stuffing two-thirds or more of the cystidia; *epicutis* of the pileus with rather numerous dermatocystidia that are  $60-85 \times 5-9 \mu$  and clavate.

*Conclusion*: The spores and dermatocystidia distinguish this species as well from *R. integra* (Linné) Fries p. p., sens. Singer (*R. Velenovskyi* Melz. & Zýára) as from *R. betulina* sens. Singer, 1939, which were possibly confused in later collections. I do not know the exact color of the spore print of the type of *R. betulina* but all of the other characters seem to put it near *R. chamaeleon* Sing. and related species of the *Urentinae* (provided the spores being "G" or darker).

RUSSULA ATROVIOLOACEA Burl. N. Am. Flora 9: 220. 1915. Type.

*Spores*  $9-12 \times 8.5-9.5 \mu$ , ornamentation  $1 \mu$  high, type IIIb, IV-VIII, V, VI; *basidia*  $35-47 \times 9.5-15.3 \mu$ ; *cystidia* rather numerous,  $47-77 \times 9.5-10.3 \mu$ , cylindrical, fusoid or constricted in the middle, many of them appendiculate (for instance with an appendage that is about  $4 \mu$  long); *epicutis* of the pileus with numerous well developed clavate dermatocystidia of  $75-115 \times 6-9.5 \mu$ . With them in the cuticle are many laticiferae. Normal hyphae  $2.5 \mu$  thick, some of them acuminate at the ends.

*Conclusion:* This species belongs to the *Urentinae*. It is rather near to *R. Cernohorskyi* and *R. nauscosa* var. *atropurpurea*, but seems to be different.

RUSSULA PAXILLOIDES Earle, Bull. N. Y. Bot. Gard. 2: 341. 1902. Type.

*Spores*  $9-12 \times 8.5-10.5 \mu$ , ornamentation  $0.9-1.3 \mu$ , type II, III, IV, rarely VI-VIII, II-IV, II-IIIa, II-IIIb, II-VIII; *basidia*  $40-65 \times 9-14 \mu$ ; *sterigmata*  $5-10 \mu$  long; *cystidia*  $43-64 \times 7.7-11 \mu$ , clavate or fusoid, with banded contents, numerous; *dermatocystidia* numerous. The dried specimen has very much the same appearance as *R. maculata*.

*Conclusion:* As long as the exact spore color of this species is unknown, it cannot be referred to any group. The most striking character of this species is the coarsely cristulate spores.

RUSSULA VETERNOSA Bres. Fungh. Mang. Velen. pl. 75. 1899, vix Fries, non Cooke neque al.

Specimen collected and determined by Bresadola in southern Tyrol, preserved at the N. Y. Botanical Garden.

*Spores*  $7.5-13 \times 6.5-11 \mu$ , ornamentation  $0.8-1.2 \mu$  high, type IV, V, VI, II-IV (i.e. with isolated zigzag-lines), VI-VIII, spines mostly isolated and very crowded; *cystidia* about  $70 \times 8.5 \mu$ , numerous; *dermatocystidia* numerous.

*Conclusion:* This species is readily distinguished from *R. badia* by its spores and by its colors. As Bresadola's conception does not fit exactly the idea of the Friesian *R. veternosa*, I proposed for it

the name *R. Bresadoliana* (Rev. Myc. 1: 84. 1936). It is quite different from *R. maculata*, and grows under *Pinus* and *Betula* in the mountain zone of the Alps and the Caucasus.

#### ACKNOWLEDGMENTS

The microscopical analyses of the types and authentic materials treated above were carried out in the Cryptogamic Herbarium of the New York Botanical Garden and at the Farlow Herbarium, Harvard University, Cambridge, Mass. The author is indebted to Dr. Fred J. Seaver and Dr. D. H. Linder, who placed the material at my disposal. Dr. Linder was also kind enough to offer most valuable linguistic advice.

# ROOT ROT OF CHAMAECYPARIS CAUSED BY A SPECIES OF PHYTOPHTHORA

C. M. TUCKER AND J. A. MILBRATH

(WITH 14 FIGURES)

## INTRODUCTION

A serious root rot disease of *Chamaecyparis* attributed to a species of *Phytophthora* has been reported from the Pacific Northwest (2) (3). The fungus attacks all sizes of trees, and is especially destructive to established landscape plantings of specimen plants or hedge rows. The disease is known to occur in Oregon and Washington, and since it apparently has been present for some time before its nature was recognized, the fungus has probably been widely distributed. The disease can readily be mistaken for transplanting injury, and hence it could be present but not recognized.

A description of the disease, the establishment of a new species of *Phytophthora* as the causal organism, and proof of the pathogenicity of this fungus are given in this report.

## SYMPTOMS OF THE DISEASE

The foliage symptoms of the disease involve gradual changes in color similar to those which occur when cypress trees die from transplanting injury. The first symptom on blue cypress is a darkening of the foliage by the formation of pigment which produces a purplish cast. As the disease progresses this purple cast and the original blue color gradually disappear until the green undercolor remains and then this variety which is normally blue might be mistaken for one of the green varieties. These first color changes are quite noticeable if the plant is adjacent to a healthy

<sup>1</sup> Published as Technical Paper No. 387 with the approval of the Director of the Oregon Agricultural Experiment Station and as Technical Paper No. 777 with the approval of the Director of the Missouri Agricultural Experiment Station. Contribution from the Botany Department of the University of Missouri and Oregon State College, coöperating.

tree, but if the diseased tree is standing alone it might be mistaken for a healthy tree. Eventually the color fades to a tan and the foliage becomes crisp and dry. When the weather is cool and damp these changes may develop over a period of 2 or 3 months, while the entire sequence occurs in 2 to 3 weeks if the weather is hot and dry. There is never any localization of symptoms; the entire foliage mass follows the same sequence of discoloration. The only foliage symptom on the green varieties is a withering and drying of all foliage, followed by the tan color indicating the death of the plant.

The fungus invades the young roots and spreads into the main trunk killing all tissues as it advances, causing a brown and water-soaked appearance. When the fungus reaches the crown of the plant it spreads out and girdles the trunk of the tree. Then the color changes of the foliage described above begin to develop. The mycelium follows the tissue just outside of the cambium layer, but the brown necrosis extends to the surface of the bark. If the outer portion of the bark is removed a sharp line of demarcation between living and dead cells is apparent a few inches above the crown of the plant. There the necrotic portion which appears a dark water-soaked brown contrasts with the white portion composed of living cells. This advancing edge of fungus invasion reaches the soil line soon after the foliage first becomes discolored. This demarcation between necrotic and living tissue is very characteristic and readily distinguishes the disease from transplanting injury.

The disease affects seedlings, rooted cuttings, small trees, or old established trees with trunks several inches in diameter.

The rate of spread and development of the disease is erratic. Some blocks of nurserystock planted in infested soil have been completely destroyed in 6 months time, while other infested plantings continue to die over a period of 3 or 4 years. The disease may spread out from an infection center, or single trees may die any place in the nursery. The type of soil drainage is an important factor in determining the behavior of the disease in a planting. When infection occurs in old established hedge rows 3 or 4 trees die each year unless there is drainage down the row in which case the spread is more rapid. When dead trees are replaced with healthy trees the latter die in about 6 months time.

## THE FUNGUS

Studies on the morphology and physiology of 11 isolates of the *Phytophthora* from *Chamaecyparis* proved them to be indistinguishable, one from another. They differed, in various respects, from the described species of the genus. The marked similarities of all

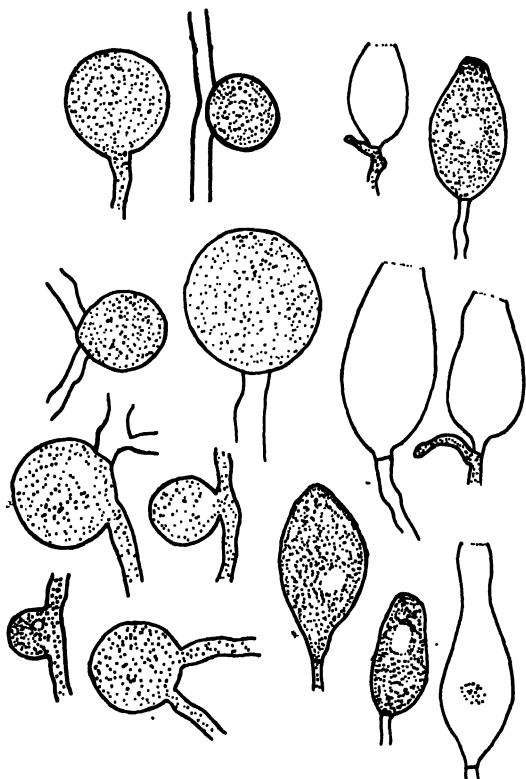


FIG. 1. *Phytophthora lateralis*. Left, terminal and intercalary chlamydospores, showing stages of the characteristic method of development of the latter. Right, sporangia with contents and evacuated.

isolates from *Chamaecyparis* indicate that the group forms a well-defined taxonomic unit. There is no evidence that the organism is merely an aberrant type comparable to those found occasionally among isolates in many species and genera of fungi. The following binomial is proposed for the new species:

**Phytophthora lateralis** sp. nov.

Hyphis primo continuis, maturitate septatis, vulgo levibus, nonnumquam tuberosis.

Sporangiis in agar cultis nullis, sed copiosis in mattis mycelialibus lavatis e solutione nutritia septem dierum 20° C. ad aquam distillatam et sterilem translatis et septem dies incubatis 20° C.; sympodialiter nascentibus in sporangiophoris non a mycelio distinctis; vulgo ovatis, obovatis, obpyriformibus; nonnumquam elongatis, aut hyalinis aut flavidis, nonpapillatis, cum obturamento apicali et refringenti et pergracili,  $26-60 \times 12-20 \mu$ , fere circa  $36 \times 15 \mu$ .

Zoosporis in sporangio formatis, biciliatis, motis concavo-convexis, quietis globosis, in diametrum 10-12  $\mu$ .

Chlamydosporis copiosis in agar cultis et in liquore, vulgo subglobosis-globosis, nonnumquam ovatis-irregularibus, cum protoplasmate granulis dense repleto, flavidis-subfuscis, cum pariete vulgo tenui nonnumquam crassa (6-7  $\mu$ ); terminalibus aut intercalaribus a latere hyphae myceli nascentibus; maturitate saepe evidenter sessilibus; in diametrum 20-77  $\mu$ ; fere circa 40  $\mu$ ; tubo germinantibus.

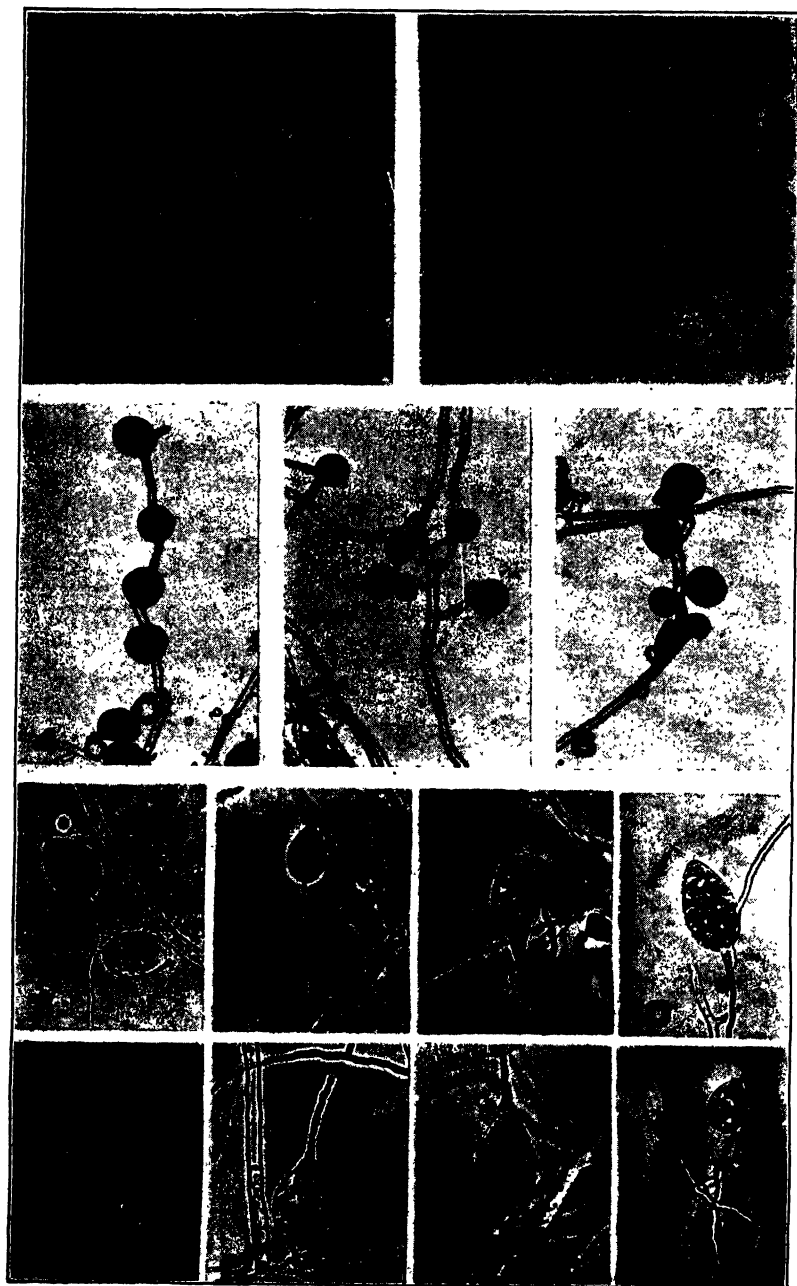
Oogoniis, antheridiis, oosporis ignotis.

Habitat in cortice vivo *Chamaecyparis Lawsonianae* Parl., Oregon, U. S. A.

Hyphae continuous when young, becoming septate with age, usually smooth, but sometimes gnarled or tuberos. Sporangia none on agar media but developing fairly abundantly on washed mycelial mats transferred from 7-day pea broth cultures (20° C.) to sterile distilled water and incubated 7 days at 20° C.; sporangia borne sympodially on sporangiophores resembling vegetative hyphae, mostly ovate, obovate or obpyriform, occasionally elongate, hyaline to lemon yellow, nonpapillate, with apical refringent plug very thin and often indistinguishable,  $26-60 \times 12-20$  micra, averaging about  $36 \times 15$  micra. Zoöspores fully differentiated within the sporangium, biciliate, reniform in motile stage, spherical in non-motile phase, 10-12 micra in diameter. Chlamydospores abundant in agar cultures and liquid media, usually subspherical to spherical, occasionally ovate to irregular, contents densely and often coarsely granular, lemon yellow to light brown; wall usually thin, sometimes thick (6-7 micra); terminal or intercalary, the latter developing as lateral swellings of the hyphae, often appearing sessile at maturity, 20-77 micra in diameter, averaging about 40 micra; germination by germ tubes. Oögonia, antheridia and oöspores unknown.

Optimum temperature on Difco corn meal agar (pH 6.1) about 20° C. Growth very restricted at 25° C. and inhibited entirely at 30° C.



FIGS. 2-14. *Phytophthora lateralis*.

The type was isolated from *Chamaecyparis Lawsoniana* Parl. in Oregon, U. S. A.

Type cultures have been deposited in the American Type Culture Collection and at the Centraalbureau voor Schimmelcultures.

*Phytophthora lateralis* exhibits certain similarities to the group of species which includes *P. Cinnamomi*, *P. erythroseptica*, *P. cambivora*, *P. cryptogea*, *P. Richardiae* and *P. Drechsleri*, particularly in its failure to produce sporangia on agar media and the nonpapillate character of the sporangia (FIG. 1, 7-10). *P. lateralis* produced sporangia only on tufts of mycelium transferred from pea broth cultures, washed and incubated in sterile distilled water, according to the procedures suggested by Rands (4) and Leonian (1). The sympodial type of development is common, new sporangia developing at the tips of branches of the sporangiophores which arise near the base of an old sporangium (FIG. 1). The resumption of growth of the sporangiophore through the base of the evacuated sporangium, and the production of new sporangia within or beyond the empty one which is frequent in other species with nonpapillate sporangia was also observed in *P. lateralis*. The species differs from others with nonpapillate sporangia in the type of development of intercalary chlamydospores which arise as lateral outgrowths from the hyphae (FIG. 1). The appearance of the chlamydospores differs markedly from that of the clustered, less fully differentiated chlamydospores or "vesicles" produced by the other species of the group. As the chlamydospores of *P. lateralis* mature they often appear to be sessile on the hyphae or supported by 2 hyphae attached to the wall in near juxtaposition (FIG. 1, 4-6).

*Phytophthora lateralis* grows on the usual agar media, such as potato dextrose agar, corn meal agar and oatmeal agar, but its rate of growth is much slower than in the related species. In this respect the species suggests the slow-growing *P. infestans* and *P. Phaseoli*, from which it is clearly defined by morphologic differences.

Frequent searches for sexual organs were made in liquid cultures and in potato dextrose and oatmeal agar cultures up to 6 months old. Chlamydospores were abundant in the old cultures but oögonia and antheridia were not found.

One of the writers (5) has shown that the temperature-growth relations of *Phytophthorae* are fairly constant within species, and

that they may be of some value in differentiating species lacking conspicuous and characteristic morphologic distinguishing characters. The 11 isolates of *Phytophthora lateralis* were grown 2 weeks at 20° C. on Difco corn meal agar (pH 6.1) in Petri plates.

TABLE 1  
GROWTH OF ISOLATES OF *Phytophthora lateralis* AT VARIOUS TEMPERATURES ON DIFCO CORN MEAL AGAR (pH 6.1)

| Isolate No. | Growth period (days) | Diameter of mycelial growth at |               |               |               |               |
|-------------|----------------------|--------------------------------|---------------|---------------|---------------|---------------|
|             |                      | 10° C.<br>mm.                  | 15° C.<br>mm. | 20° C.<br>mm. | 25° C.<br>mm. | 30° C.<br>mm. |
| 459         | 4                    | t *                            | 13            | 14            | 0-sl          | 0             |
|             | 8                    | sl                             | 18            | 25            | sl            | 0             |
| 513         | 4                    | t                              | sl            | 12            | sl-14         | 0             |
|             | 8                    | sl                             | 14            | 25            | sl-16         | 0             |
| 535         | 4                    | t                              | sl            | 16            | t             | 0             |
|             | 8                    | sl                             | 18            | 29            | t             | 0             |
| 536         | 4                    | 0                              | sl            | 14            | t-14          | 0             |
|             | 8                    | sl                             | 15            | 28            | sl 15         | 0             |
| 567         | 4                    | t                              | sl            | 15            | 0 t           | 0             |
|             | 8                    | 11                             | 15            | 25            | 0-sl          | 0             |
| 568         | 4                    | t                              | sl            | 16            | 0-sl          | 0             |
|             | 8                    | 13                             | 21            | 29            | 0 11          | 0             |
| 572         | 4                    | t                              | sl            | 13            | 0-sl          | 0             |
|             | 8                    | 11                             | 16            | 24            | t-sl          | 0             |
| 581         | 4                    | t                              | 11            | 17            | 0 t           | 0             |
|             | 10                   | 18                             | 22            | 32            | 0-t           | 0             |
| 582         | 4                    | t                              | sl-12         | 15            | 0 sl          | 0             |
|             | 10                   | 16                             | 19            | 30            | 0-sl          | 0             |
| 583         | 4                    | t                              | 13            | 15            | sl            | 0             |
|             | 10                   | 15                             | 25            | 28            | sl            | 0             |
| 584         | 4                    | t-sl                           | 15            | 17            | 15            | 0             |
|             | 10                   | 18                             | 28            | 31            | 23            | 0             |

\* t—trace, growth barely discernible. sl—slight, growth easily discernible, but too slight for measurement.

The cultures were cut into 5 mm. squares, one of which was transferred to the center of each of 10 Petri plates of the same medium. The plates were incubated, in pairs, at 10° C., 15° C., 20° C., 25° C. and 30° C. The mycelial growths were measured after 4 and 8 or 10 days. The results are given in Table 1.

The isolates behaved very similarly in their responses to various temperatures. No. 584 proved somewhat more resistant to 25° C. than the other 10 isolates. All isolates grew very slowly at 10° C., somewhat more rapidly at 15° C., and made their best growth at 20° C. A temperature of 25° C. is apparently very near the maximum, resulting in reduced growth of all isolates. At 30° C. there was no growth and, after 8 days exposure, the fungus in the inocula was dead.

The low temperature requirement for growth of *Phytophthora lateralis* is similar to that of *P. hibernalis*, *P. infestans* and *P. Syringae*, where growth is inhibited at 25° C. (5). However, these 3 species all possess distinguishing morphologic features quite different from those of *P. lateralis*.

The type of mycelial growth on Difco corn meal agar at 20° C. has no distinguishing characters. Growth is regularly circular, submerged, frequently slightly rhizoidal in appearance.

Apple (Delicious) fruits and potato (Idaho Russet) tubers were inoculated with each of the 11 isolates by inserting a tuft of mycelium into a short slit 7 mm. in depth. The wounds were covered with white petrolatum to prevent drying, and the fruits and tubers were incubated at 20° C. After 20 days the apple fruits showed a dark brown, firm, usually sharply delimited area of invaded tissue  $\frac{1}{2}$  to 1 inch in diameter at most of the wounds. The *Phytophthora* was reisolated. The potato tubers remained entirely free from evidence of infection.

The fungus may be identified readily by the nonpapillate sporangia and the large intercalary chlamydospores which arise as lateral swellings on the hyphae, resulting in a characteristic sessile or double-stalked appearance. The slow growth and low temperature requirement are valuable confirmatory characters.

#### PATHOGENICITY

*Phytophthora lateralis* is readily isolated by taking pieces of tissue near the cambium area showing the advancing edge of the necrosis, and placing these on potato dextrose agar. If isolations are made from the crown of the trees when the foliage first becomes discolored it is not uncommon to obtain pure cultures of the *Phy-*

*tophthora* from every piece of such tissue. *Fusarium* and other fast growing secondary organisms follow closely behind the *Phytophthora*, and these fungi are the only ones recovered from dead roots or tissue that has been necrotic for some time.

*Phytophthora lateralis* has been isolated from 23 different collections of *Chamaecyparis Lawsoniana* Parl. var. *alumi* Beiss., 1 collection of *C. Lawsoniana* Parl. var. *erecta* Sudw., and 1 collection of *C. obtusa* Sieb. & Zucc. var. *gracilis* Nash. The collections consisted of 1 to 10 trees from different localities and yearly collections from the same locations. *C. Lawsoniana* Parl. var. *alumi* Beiss. is the predominating variety used for ornamental purposes and is therefore the frequent host for the fungus.

TABLE 2  
INOCULATIONS WITH *Phytophthora lateralis*

| Method of inoculation  | No. of inoculations | No. of plants inoculated | No. of plants positive |
|------------------------|---------------------|--------------------------|------------------------|
| Agar cultures.....     | 9                   | 33                       | 30                     |
| Pea broth cultures.... | 7                   | 40                       | 35                     |
| Soil.....              | 2                   | 12                       | 12                     |
| Checks.....            | 7                   | 21                       | 0                      |

The pathogenicity of *P. lateralis* is readily demonstrated. Three methods of inoculation have been used and all appear equally effective, as shown in Table 2. When the fungus was growing on potato dextrose agar media bits of the mycelium were placed under the bark through wounds on the crown or on the roots. Checks were similarly treated with sterile media. Cultures of the fungus in pea broth were introduced into the soil about the roots of the plant. Soil inoculations were made by taking the soil and roots from around diseased plants and mixing them with the soil in which the cypress were to be grown.

Small, well rooted plants of *Chamaecyparis Lawsoniana* var. *alumi* have been used in all of these pathogenicity studies. Further pathogenicity studies connected with another phase of this problem indicate that all varieties of *C. Lawsoniana* are susceptible, some of the varieties of *C. obtusa* are susceptible while others are resistant, and that all varieties of *C. pisifera* show resistance. None of the other conifers are known to be susceptible.

## SUMMARY

A root rot of *Chamaecyparis* occurring in Oregon and Washington is attributed to *Phytophthora lateralis*.

The fungus invades the young roots and eventually girdles the trunk; characteristic color changes of the foliage accompany the destruction of root and stem tissues and infected trees are killed.

In culture the causal fungus grows slowly on agar media. The optimum temperature is about 20° C.; growth is reduced at 25° C., and inhibited at 30° C.

The disease has been identified in *Chamaecyparis Lawsoniana* var. *alumi*, *C. Lawsoniana* var. *erecta* and *C. obtusa* var. *gracilis*.

UNIVERSITY OF MISSOURI,  
COLUMBIA, MISSOURI,  
AND  
OREGON STATE COLLEGE,  
CORVALLIS, OREGON

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## EXPLANATION OF FIGURES

All figures are of *Phytophthora lateralis*.

FIG. 1. Drawings by C. M. Tucker. Left, terminal and intercalary chlamydospores, showing stages of the characteristic method of development of the latter. Right, sporangia with contents and evacuated.

FIG. 2-14. Photomicrographs of unstained water mounts of living material by F. P. McWhorter and J. A. Milbrath. (2) Young mycelium ( $\times 100$ ) recently isolated to show large tortulous type of branching; (3) mycelium ( $\times 100$ ) from older culture showing gnarled branching; (4-6) characteristic development of chlamydospores ( $\times 100$ ); (7-14) characteristic development of sporangia ( $\times 200$ ); (7) evacuated sporangium and sporangium with contents; (8-10) characteristic types of sporangia; (11-13) germination of sporangia to produce new mycelium; (14) an evacuated sporangium followed by the development of a second sporangium.

# A NEW FUNGOUS PARASITE ON DUNG-INHABITING ASCOMYCETES

MARION L. LOHMAN<sup>1</sup>

(WITH 15 FIGURES)

In December 1940 during the routine study of *Ascobolus stercorearius* in a laboratory class in cryptogamic botany, a student, Mr. Joseph Lipps, had the good fortune to discover an ascus-borne chytridiaceous sporangium emitting its zoöspores. With subsequent inspections of some of the various kinds of ascocarps and spores to be found on cow dung, I have seen many additional sporangia upon asci and ascospores of *A. immersus*, *A. Leveillei*, and *A. stercorearius*, and in a very few instances upon cells of the exiple in fructifications of the last named species.

Inasmuch as the current taxonomic treatments of the Chytridiales include no records of non-filamentous Phycomycetes upon any species of the Ascomycetes, I extended the observations on this parasite to include a survey of apothecia that developed in moist-chamber cultures of dung from several pastures, incorporating studies on the capacity of the organism to infect various Ascomycetous fungi as determined by rather crude but useful inoculation tests in hanging drop cultures.

While chytridiaceous fungi are of common occurrence on non-filamentous and Oömycetous Phycomycetes, they apparently are rarely associated with higher filamentous fungi. With special reference to the Rhizidiaceous forms in the latter association, one finds in the literature but two species, namely, *Olpidium Uredinis* (Lagerh.) A. Fischer, on uredospores of *Puccinia*, and the tropical *Rhizophidium fungicolum* Zimm. in association with hyphae of

<sup>1</sup> In the study of this fungus I am indebted to Mr. J. D. Lipps and Mr. F. S. Shuttleworth for certain field collections; to Dr. G. W. Prescott for the tentative specific determinations of the Algae mentioned; and to Prof. John N. Couch for helpful communications concerning his observations on the habit of the fungus in culture. The names of Discomycetous fungi mentioned herein are after Seaver (5).

*Gloeosporium Theobromae*. Zimmermann (7) observed that the zoöspores of the *Rhizophidium* infected only the hyphae of the *Gloeosporium*, while hyphae of other fungi, probably Ascomycetes, were intermingled.

Although the present fungus on *Ascobolus* and other Ascomycetes conforms to the genus *Rhizophidium* in consideration of the shape of its sporangia, number of exit papillae, and size and shape of zoöspores, because of the presence of a distinct and moderately large subsporangial vesicle in certain sporangia it is herewith tentatively referred to *Phlyctochytrium* with the following diagnosis:

***Phlyctochytrium Lippsii*, sp. nov. (FIGS. 1-15)**

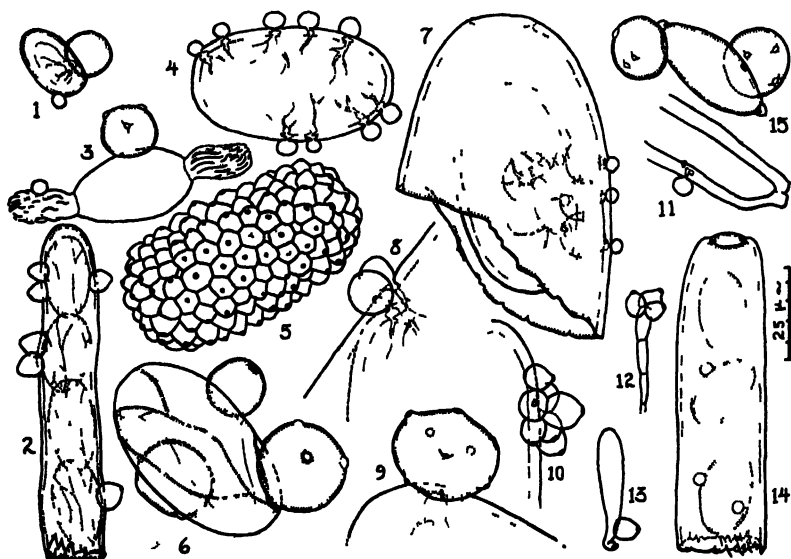
Fungus perniciosus in sporidiis fungorum ascophororum fimicolum, hic quidem visum est—Zoosporangiis ex parte intramatrici orientibus, subglobosis aut pyriformibus, sessilibus vel rarissime brevi-stipitatis, levibus, subhyalinis, tenuiter tunicatis, 7-36  $\mu$  diam., papillis 1-3-10-ornatis; zoosporis motis formantibus in sporangibus minoribus sex octo, majoribus circa sexaginta, subgloboso-ellipsoideis, hyalinis, 3-4  $\mu$  diam., per orificia inornata singulatim liberatis; cilio circa 25  $\mu$  longo; cellula intramatrici 2-10  $\mu$  diam., plerumque ignota; rhizinis angustis ramosis radiantibus crassis bifurcisve praedita.

Obs.: Fungus in natura et culturis in specibus *Ascoboli*, *Ascophani*, *Lasioholi* et *Sordariac* prope Bloomington, Indiana, U. S. A.

Zoösporangia external to nutritive host cell, single or aggregated, occasionally short-stalked but typically sessile, obovate when densely clustered, to globose or globose-flattened when free, 7 to 36  $\mu$  in diameter, with smooth, hyaline to pale yellowish wall which at maturity in the larger individuals is approximately 1  $\mu$  in thickness, appearing double, with 1 to 3, occasionally as many as 10, smooth, obtusely rounded exit papillae; zoöspores as few as 6 or 8 in small sporangia, as many as 60 or more in the largest; at first narrow elliptic, 3.5  $\mu$  long but after swimming a few minutes elliptic-ovoid, 3 to 4  $\mu$  in diameter, with one or two oil drops and posterior flagellum about 25  $\mu$  long—at 15 to 20° C. swimming before emission, then escaping freely without vesicle formation and swimming away in a zigzag course; subsporangial vesicle thin-walled, variable in size and shape, 2 to 4  $\mu$  in diameter and bead-like, or occasionally 8 to 10  $\mu$  in diameter and broadly fusoid—sometimes not evident; rhizoids dendroid and delicate but sometimes from the bead-like apophysis stoutish bifurcate, with delicate terminal branching; resting spores not observed; sporangia viable after normal desiccation for 6 weeks at room temperature.



Observed on *Ascobolus immersus*, *A. Leveillei*, *A. stercorarius*, *Ascophanus Holmskjoldii*, *Lasiobolus equinus*, and *Sordaria coronifera* Grove; typically upon free or undischarged ascospores of *Ascobolus* species in the vicinity of Bloomington, Momoe County, Indiana



FIGS 1-15 Sporangial development in *Phlyctochytrium Ippsi* 1, 2 on *Ascobolus stercorarius*, 3, on *Sordaria coronifera* (appendages of ascospore swollen), 4-10, on *Ascobolus immersus* ascospores with infection through the ascus wall in figures 7 and 8 the sporangia developed directly upon the ascospore in the former and external to the ascus in the latter (figure 6 illustrates the more typical sporangial condition when infections are few and also shows the markings for the entire surface of a typical, brownish violaceous ascospore, figure 7 illustrates four sporangia on the uppermost of four infected ascospores of a single ascus), 11-14, on hair cell, paraphysis, young ascus, and undischarged ascospores of *Lasiobolus equinus* (see explanations in text), 15, mature, functional sporangia on ascospore of *Ascophanus Holmskjoldii*

#### OBSERVATIONS ON FUNGI INFECTED IN THE FIELD

Fructifications and free ascospores of various fungi found upon cow dung were examined from samples taken in five pastures in the vicinity of Bloomington. The first was gathered December 4, 1940; the last April 4, 1941. In the laboratory the samples were

kept in moist chambers and sterile brook water was added to maintain the necessary moisture and to provide at one or more intervals a free water film upon the surface of the ascocarps. Although species of *Ascobolus* were of first interest, ascocarps of *Ascophanus* and *Lasiobolus* and algal cells were examined with equal care. Apothecia were dissected for inspection and previously discharged ascospores were obtained by scraping the surface of the substratum.

The parasite was found on one or more species of *Ascobolus* in samples from three pastures of the following location: Upper watershed of Griffy Creek Reservoir (collections of December 4 and February 15); Dolan watershed of Bean Blossom Creek, 8 miles distant from the former (March 12); Lower watershed of Griffy Creek, one mile from the first pasture (April 4). In each of these collections of samples *A. immersus* was present and infected. Samples taken April 4 in two additional distant pastures yielded only uninfected *A. stercorarius* and a third collection of samples (March 14) from the first location yielded only uninfected *Ascophanus carneus* and *Lasiobolus equinus*.

Altogether, the study of field samples for naturally infected species suggests that the parasite occurs most frequently on *Ascobolus immersus*.

The collection of April 4 in the lower watershed of Griffy Creek afforded the best opportunity to determine the probable relationship of the parasite with certain algae which had been seen sparingly in a number of the samples, resting upon basal portions of dissected apothecia and filling broken vessels of woody fragments in the dung. In this collection ascocarps of *Ascobolus immersus* could not be found but many free ascospores were present in the heavy algal films over the substratum and in beetle excrement both in cavities and upon the surface of the dung. The chytrid sporangia occurred on many of these spores. They could not be found, however, on asci and ascospores, or other cells of *Ascophanus carneus* which was fruiting sparingly, or upon cells of *Chlamydomonas fungicola*, which was very abundant, although mostly encysted, or upon *Hormidium fragilis* which was moderately abundant in both the vegetative and zoösporic phases.

On the assumption that only one chytridiaceous fungus was responsible for the infections observed, algal cells, slide-trapped ascospores, and apothecial fragments with asci were tested for infection in hanging drops of sterile brook water, using infected ascospores or suspensions of zoöspores as inoculum. In these tests the parasite developed upon additional species of fungi.

#### SPECIES INFECTED IN INOCULATION TESTS

Inoculation tests were observed in hanging drops in "Van Tiegham" cells using for the most part ascospores trapped on sterile slides placed above fragments of dung.<sup>2</sup> Cultures established with hymenial fragments afforded some observations on zoöspore infection through the ascus wall but these were less satisfactory because of protozoan disturbances by the third day. Even though cultures were not purified, it is believed that the results of these tests indicate in some degree the ability of the parasite to infect ascospores of various genera of Ascomycetes.

It was observed that ascospores of *Ascobolus immersus* and *A. stercorarius* regularly developed sporangia, in many instances apparently to the point of complete utilization of the protoplasts. Two sporangia, one inactive, were seen on a single ascospore among several hundred in the case of *Sordaria coronifera* (FIG. 3) and one to three mature sporangia on each of six spores among several hundred in the case of *Ascophanus Holmskjoldii* (FIG. 15). With the latter species, however, three asci containing mature ascospores were found with typical sporangia 10 to 12  $\mu$  in diameter—one ascus with five sporangia, one with two, and one with a single sporangium opposite the lowermost ascospore.

Infections found on *Lasiobolus equinus* were less conclusive (FIGS. 11–14). While no sporangia were observed on hundreds of ascospores examined, small empty sporangia were seen on

<sup>2</sup> Reference here is to a modified Van Tiegham cell, inasmuch as garden hose gaskets, washed in alcohol and then soaked in sterile water, were substituted for the usual glass cylinders. With the culture cells stacked in large moist chambers, drop cultures were maintained by this mechanism without difficulty, the films of water between surfaces of glass and rubber preventing rapid evaporation. In practice, after a lengthy microscopic examination, the dry gasket is simply replaced by a moist one, or water added at the edge.

rounded basal and hair cells of the exciple, at the base of an immature ascus, and on tips of several paraphyses, with respect to one of which zoöspores were observed being discharged from three terminal sporangia. They were of the characteristic shape and habit but smaller, measuring  $3 \times 2.5 \mu$ . Zoöspores were observed swimming within one ascus which had discharged four of its spores, entrance to which, presumably, they had gained by way of the ascostome. Twelve hours later they were seen encysted on two of the ascospores. After three days, when the preparation was abandoned, they had not enlarged beyond the encystment stage (FIG. 14).

Ascospores and asci of *Ascophanus carneus* remained uninfected. This species was abundant on dung collected in different pastures on March 14 and April 4, and careful inspection of many dissected apothecia revealed no infections. In the first of these collections *Ascobolus* species could not be found but in the second infected free ascospores of *A. immersus* were abundant on the surface in areas containing apothecia of the *Ascophanus*.

The spore suspension drops regularly contained many ascospores of *Sordaria fimicola* (Rob.) Ces. & De Not. and a few of the groups of spores of *Ryparobius sexdecimsporus* and *Sporormia megalospora* Auersw. These spores remained uninfected.

Four preparations of *Chlamydomonas* and *Hormidium* mixed were inoculated with infected ascospores of *Ascobolus immersus*. These were studied until discarded on the eighth day and infected algal cells were not found. The ascospores, however, during this time showed increasing numbers of sporangia, some with more than a hundred, mutually compressed (FIG. 5), others with as many as two dozen large sporangia, the ascospores then existing as collapsed cases.

#### DISCUSSION AND SUMMARY

That the relative size and position of the subsporangial vesicle in this fungus varies with the nature and continuity of the substratum which the infection strand encounters is evidenced by infections first through the ascus wall and then in turn through the double wall of the ascospore (FIGS. 6-9). While the presence

of the vesicle is retained as a feature for the separation of *Phlyctochytrium* and *Rhizophidium* in systematic treatments (2, 4), Fitzpatrick (2), Couch (1), Sparrow (6), and Karling (3), in recognition of possible variability in this particular feature of chytrid morphology, question its usefulness either in delimiting genera or in the generic disposition of certain species. The ranges of variability of about  $30\ \mu$  in diameter of the sporangia and from 1 to 8 or 10 exit papillae are not extreme in comparison with certain species of *Rhizophidium*.

Observations on the occurrence of this species suggest that it is primarily a parasite of ascospores of species of *Ascobolus* and of *A. immersus* in particular. Ascospores of the latter, either because of some singular feature of the wall or some chemical stimulus together with an abundant food source, attract the zoöspores and become infected to a greater degree than do spores of other species of *Ascobolus* or of other dung-inhabiting Ascomycetes. Perhaps in the absence of ascospores of *A. immersus* those of other species would show a higher incidence of infection when supplied with zoöspores.

Destruction of the endoplast in ascospores of *Ascobolus immersus* is evidenced by collapsed ascospore cases and in rare instances by the inward discharge of zoöspores whereupon the body of the ascospore becomes a swarming mass of zoöspores with no indication of any internal sporangia or any endoplasmic materials impeding them in their rapid swimming.

*Chlamydomonas fungicola* and *Hormidium fragilis* were found in abundance on substrata in which this fungus occurred on *Ascobolus immersus*. These species were not found to be infected and all attempts to establish infections upon them artificially were unsuccessful.

DEPARTMENT OF BOTANY AND BACTERIOLOGY,  
INDIANA UNIVERSITY

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## NOTES AND BRIEF ARTICLES

### MUSHROOM POISONING CAUSED BY *LACTARIA GLAUDESCENS*

On July 28, 1941, a telephone message was received from the Children's Hospital of Washington, D. C., in regard to a probable case of mushroom poisoning which had resulted in the death of a two and a half year old child. Mushrooms from the same collection had also been eaten by the mother of the child, who although having been made very ill eventually recovered.

The mushrooms were collected in nearby Maryland Friday morning, July twenty-fifth and eaten at about one o'clock of the same day. Only five mushrooms were cooked and the child ate only a small piece of one about an inch square. The mother ate three of the specimens and pronounced them very good. Nausea and intestinal disturbances followed in a short time and when the husband returned from work in the late afternoon he found the mother and child very ill. In the evening he took them to a physician who gave them some medicine but did not use a stomach pump. The child was ill but walked around the room a little before going to bed, ate a cookie, and asked for water. According to the mother's statement he became worse during the night and by morning was semiconscious. His condition was so alarming that the father again took him to a physician in Rockville, Md., who, recognizing the seriousness of the case, advised the father to take him to the Children's Hospital in Washington. In spite of the excellent care given the child at this Institution he died Tuesday morning, July 29th, 1941, at 12.10 A.M. The mother was not attended at a hospital, and was very ill for a week or so, suffering extreme nausea and severe abdominal pains. As far as could be learned no marked mental disturbances, as intoxication or hallucinations, were produced although extreme nervousness continued throughout the illness.

The possibility of a mixed collection of mushrooms was carefully considered, but doubt as to the species responsible for the trouble

was eliminated. The death of the child and recovery of the mother may be explained by the fact that the child was born with a bad heart and was always delicate.

The specimens submitted for examination and said to be part of those eaten were determined as *Lactaria glaucescens* Crossland. Spores recovered from washings of the child's stomach, after all solid material had been eliminated were identical with the spores of the specimens submitted for examination.

Certain authorities have considered *Lactaria piperata* (L.) Pers. and *L. glaucescens* Crossland identical, but the following characters as exhibited by *L. glaucescens* would seem to establish it as a distinct species: the extremely fine crowded gills, the greenish color of the milk, the small spores and different spore markings.<sup>1</sup>

This is the first case of poisoning caused by eating *L. glaucescens* which has come to our attention. The danger presented by this species is increased by its general resemblance to *Lactaria piperata* which is ordinarily considered edible. Its peppery taste might act as a deterrent in its use as food, but as most descriptions of *L. piperata* mention this as a transitory character which disappears in cooking it would be of little value. To the mycophagist or amateur collector who lacks a microscope, the two striking characters for identification would be the narrow, crowded gills and the greenish color of the milk. This plant is rendered even more dangerous because of its wide geographical distribution and its appearance from early spring until late fall.—VERA K. CHARLES

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#### A CLASSIFICATION OF AQUATIC PHYCOMYCETES

The following outline of a classification of the Aquatic Phycomycetes is one which has been gradually evolved during the course of some years of study of these fungi. Like all such objects it is undoubtedly an imperfect structure and represents nothing more than one person's ideas of the natural affinities of the diverse aquatic organisms now placed in the Phycomycetes.

<sup>1</sup> Grateful acknowledgment is made to Dr. G. S. Burlingham who examined the spores and verified the determination of the species.



As may be readily seen, a primary distinction is drawn on the basis of the structure of the zoospore, although there are other, correlated characters. Parallelisms in body plan are evident among members of the uni- and biflagellate series. The first three orders are believed to be closely related. The Saprolegniales and Leptomitales also represent related orders. The natural affinities of the others, however, are indeed obscure. The Chytridiales are considered to be composed of two parallel groups which, while differing from one another in their method of zoospore discharge (inoperculate or operculate), are often of similar body plan. Whether or not the Lagenidiales (the former Ancylistales) has been made too inclusive must await the test of time.

No originality is claimed for some features of the classification.<sup>1</sup> It can be said, however, that it has been arrived at independently and only after a study of a great many of the organisms concerned.

#### UNIFLAGELLATE SERIES

##### Order I. CHYTRIDIALES

###### INOPERCULATAE

###### Fam. 1. Olpidiaceae

*Nucleophaga*  
*Sphaerita*  
*Olpidium*  
*Pleotrachelus*  
*Plasmophagus*  
*Rozella*  
*Olpidiomorpha*  
*Pringsheimiella*  
 (? *Myrophagus*)

###### Fam. 2. Achlyogetonaceae

*Achlyogeton*  
*Septolpidium*  
*Bicricium*

###### Fam. 3. Synchytriaceae

*Micromyces*  
*Micromycopsis*  
 (*Synchytrium*)

###### Fam. 4. Phlyctidiaceae

Sub. fam. Phlyctidioideae  
*Phlyctidium*

*Achlyella*

*Rhizophydium*

*Dangcardia*

*Phlyctochytrium*

*Blyttiomycetes*

*Rhizidiopsis*

*Physorhizophydium*

*Podochytrium*

*Saccomyces*

*Scherffeliomyces*

*Coralliochytrium*

###### Sub. fam. Entophlyctoideae

*Entophlyctis*

*Diplophlyctis*

*Mitochytridium*

*Rhizosiphon*

*Aphanistis*

###### Fam. 5. Rhizidiaceae

###### Sub. fam. Rhizidioideae

*Sporophlyctidium*

*Rhizidium*

<sup>1</sup> For the most part, only well established genera are listed.

- Rhizophlyctis*  
*Nowakowskia*  
 Sub. fam. Obelidioideae  
*Obelidium*  
*Rhizoclostridium*  
*Asterophlyctis*  
*Siphonaria*  
 Sub. fam. Polyphagoideae  
*Polyphagus*  
*Sporophlyctis*  
*Endocoenobium*  
 Fam. 6. Cladochytriaceae  
*Catenaria*  
*Cladochytrium*  
*Amoebochytrium*  
*Physocladia*  
*Coenomyces*  
 (Fam. 7. Physodermataceae)  
*(Physoderma)*  
*(Urophlyctis)*
- Order II. BLASTOCLADIALES  
 Fam. 1. Blastocladiaceae  
*Clavochytridium* (?)  
*Sphacrocladia*  
*Blastocladiella*  
*Allomyces*  
*Blastocladia*
- OPERCULATAE  
 Fam. 8. Chytridiaceae  
 Sub. fam. Chytridioideae  
*Chytridium*  
*Catenochytridium*  
 Sub. fam. Zygorhizidioideae  
*Zygorhizidium*  
 Sub. fam. Macrochytrioideae  
*Macrochytrium*  
 Sub. fam. Endochytrioideae  
*Endochytrium*  
*Nephrochytrium*  
 Fam. 9. Nowakowskiellaceae  
 Sub. fam. Nowakowskielloideae  
*Nowakowskiella*  
*Septochytrium*  
 Sub. fam. Megachytrioideae  
*Megachytrium*  
*Tetrachytrium*  
*Zygochytrium*
- Order III. MONOBLEPHARIDALES  
 Fam. 1. Monoblepharidaceae  
*Monoblepharis*  
*Monoblepharella*  
*Gonapodya*  
*(Myrioblepharis ?)*

## [APPENDIX TO UNIFLAGELLATE SERIES]

- Fam. 1. Hyphochytriaceae  
*Latrostium*  
*Rhizidiomyces*  
*Hyphochytrium*

BIFLAGELLATE SERIES <sup>2</sup>

- Order IV. PLASMODIOPHORALES  
 Fam. 1. Plasmodiophoraceae  
*Woronina*  
*Octomyxa*  
*Plasmodiophora*  
*Ligniera*  
*Tetramyxa*  
*Sorodiscus*
- Order V. SAPROLEGNIALES  
 Fam. 1. Ectrogellaceae  
*Ectrogella*  
*Eurychasma*  
*Eurychasmidium*  
*Aphanomycopsis*  
 Fam. 2. Thraustochytriaceae  
*Thraustochytrium*

<sup>2</sup> Professor J. N. Couch has suggested that this series be divided into two, one with flagella of very unequal length (Plasmodiophorales), the other with equal or nearly equal flagella.

## Fam. 3. Saprolegniaceae

*Pythiopsis**Aplanos**Saprolegnia**Isoachlya**Leptolegnia**Achlya**Protoachlya**Sommerstorffia**Aphanomyces**Plectospora**Calyptrolegnia**Thraustotheca**Dictyuchus**Brevilegnia**Geolegnia*

## Order VI. LEPTOMITALES

## Fam. 1. Leptomitaceae

*Leptomitus**Apodachlya**Apodachlyella*

## Fam. 2. Rhipidiaceae

*Sapromyces**Rhipidium**Aruiospora**Mindeniella*

## Order VII. LAGENIDIALES

## Fam. 1. Olpidiopsidaceae

*Pseudolpidium**Olpidiopsis**Petersenia**Pythiella**Pseudosphaerita*

## Fam. 2. Sirolpidiaceae

*Sirolpidium**Pontisma*

## Fam. 3. Lagenidiaceae

*Myzocyttium**Lagenidium**Resticularia**(Lagena)*

## Order VIII. PERONOSPORALES

## Fam. 1. Pythiaceae

*Zoöphagus**Pythiomorpha**Pythiogeton**Pythium*

F. K. SPARROW, JR.

## A NEW SPECIES OF MYCETOZOA

Accompanied by Mr. Joseph H. Rispaud, I attended the Foray of the Mycological Society of America held at Macdonald College, Quebec, August 25–28, 1941. Macdonald College is situated at Ste Anne de Bellevue, on the Island of Montreal, nearly thirty miles west of the City of Montreal. On August 26, at Ste Dorothee on the Island of Jesus, which island is situated northwest of the Island of Montreal, and separated from it by the river La Prairie, we found a small development of about 25 sporangia of an unusual *Badhamia*, which, later in the laboratory of Macdonald College, was the subject of considerable interest. An effort was made to obtain other collections, and on the following day Mr. Rispaud succeeded in discovering another small fruiting on the campus of Macdonald College. On the morning of the last day of the Foray, August 28, at St. Martin, also on the Island of Jesus,

we made the third and best collection, more ample and representative. All three collections are alike, and on the bark of dead spruce twigs and sticks. Following the last excursion, the party proceeded to the Montreal Botanical Garden where a Laboratory of Plant Pathology was dedicated in honor of Dr. John Dearness, a veteran Canadian mycologist. This event closed a successful four-day foray of the Mycological Society of America.

The *Badhamia* appears to be an undescribed species of the Mycetozoa, and I have great pleasure in describing and naming it after Dr. John Dearness, a past President of the Society.



FIG. 1. Spores of *Badhamia Dearnessii* ( $\times 1000$ ).

### ***Badhamia Dearnessii* sp. nov.**

Plasmodium incognitum; sporangia dissipata vel gregaria, in arcis parvis, plerumque globosa, sessilia basibus angustis, subalba, 0.5–1 mm.; murus sporangiorum tenuis, membranaceus, afferens granula calcis saepe amplificata, ubi calx deest exhibens colores iridis; capillitium reticulum calcis, album, in loculis aliquibus ubi calx deest admodum tenue et subhelvolum; sporae separatae, globosae, plene minute spinulosae, purpureo-fuscae, praeter cingulum pallidum angustum, 13–16  $\mu$  diam. Habitat super cortice Piceae albae mortuae.

Plasmodium? Sporangia scattered or loosely clustered in small developments, globose to subglobose, sessile on a narrow base, grayish white, 0.5–1 mm. diam.; sporangial wall membranous with deposits of white lime-granules often arranged to show veins or thickenings, iridescent when lime-less; capillitium a network of slender strands scantily charged with white lime-granules, the latter

sometimes absent when the capillitium is very delicate and may appear pale yellow in color; spores free, globose, minutely and closely spinulose over the entire surface, purplish brown with a narrow, pale area around the spores, 13–16  $\mu$  diam.

In some respects, *Badhamia Dearnessii* resembles several other sessile forms of *Badhamia*, but the spore characters, and particularly the pale bands, are diagnostic. The spore color is a little darker than usually understood as purplish brown. The occasional absence of lime in the capillitium does not alter its form or shape appreciably, except to make it frail and delicate. The pale yellow color observed may be the color of the thin membrane usually enclosing the lime-granules of the capillitium.

The third collection, N. Y. B. G. No. 2530, is regarded as the type collection, and the specimen deposited in the Herbarium of the New York Botanical Garden is the type. Portions of the type collection have been distributed to the United States National Museum, the State University of Iowa, the Farlow Herbarium, the University of Toronto, the Montreal Botanical Garden, Macdonald College, and several students in Ontario. The other two collections, N. Y. B. G. Nos. 2512 and 2514, are regarded as co-types.—ROBERT HAGELSTEIN.





PLECTANIA COCCINEA

# MYCOLOGIA

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No. 2

## PLECTANIA COCCINEA

FRED J. SEAVER

(WITH COLORED ILLUSTRATION)

Some of my earliest and most cherished memories as a student in the State University of Iowa are the frequent rambles in company with the late Professor B. Shimek over the hills and along the banks of the Iowa River and some of its tributaries, especially Turkey Creek, the scene of many a happy outing.

And how well do I recall the thrill when first encountering the brilliant "scarlet cup" (*Plectania coccinea*), as it beamed up as though to welcome us for this is one of the harbingers of spring-time, and one of the first of its kind to appear when the snow is gone. Occasionally one may be found in the very late autumn, but it is essentially a spring species.

This, most beautiful of its group, did much to arouse in me an interest in the study of the cup-fungi, and perhaps more than any other one thing is responsible for the shaping of my career in life. I feel, therefore, that it is entitled to a prominent place in the present publication.

Copy for the accompanying illustration was supplied by Dr. B. O. Dodge, and was made by Clara D. Epling from material collected by him in Wisconsin for the species has a wide distribution throughout North America and Europe, but often like the "modest violet" remains unseen except as it is spied by the prying eyes of the naturalist. The reproduction is about natural size.

No reprints of this note will be made, but the illustration appears in the Supplemented Edition of North American Cup-fungi, just off the press.

THE NEW YORK BOTANICAL GARDEN

[MYCOLOGIA for January-February (34: 1-118) was issued February 1, 1942]



# THE SPHERICAL GALL RUST OF JACK PINE

RENÉ POMERLEAU

(WITH 1 FIGURE)

Three types of gall rusts have been found in Quebec on *Pinus Banksiana*. Two of them are well known: the fusiform gall caused by *Cronartium Commanndrae* and the effused gall of the base of the stem caused by *C. Comptoniae*. A third type, which has been observed for several years in Quebec, presents true globose galls (FIG. 1, A, B, C) related to the eastern gall rust of *Cronartium Quercuum* and more closely to the western one known under the name of *C. coleosporioides*.

Although the existence of *C. Quercuum* has been mentioned on *Pinus Banksiana* of the northeast, all spherical galls cannot easily be considered as belonging to this species. These galls are mostly found in far north regions where oak, the alternate host, is from 200 to 300 miles distant at least.

The known range of *C. coleosporioides* of western species of hard pines has also left much doubt on the possible relationship with our eastern gall on Jack Pine. The striking similarity of this disease with the Woodgate rust of *Pinus sylvestris*, so common in plantations in this part of the continent, has also complicated the problem.

Several attempts have been made to directly inoculate pine by aeciospores but no successful result was obtained. This problem was left unsolved for many years up to the end of the summer 1941. In a Jack Pine stand, located on the north shore of the St. Lawrence River at about 300 miles northeast of Quebec city, the author was looking for possible secondary hosts of the two existing pine rusts: the fusiform and the spherical type, when the telial stage of *C. Commanndrae* was abundantly found on *Commanndra livida*. Associated with this herbaceous plant and shrubby species like *Vaccinium Vitis-Idaea* and *V. pennsylvanicum*, another plant, identified as *Melampyrum lineare* was also found bearing telial columns (FIG. 1, D).

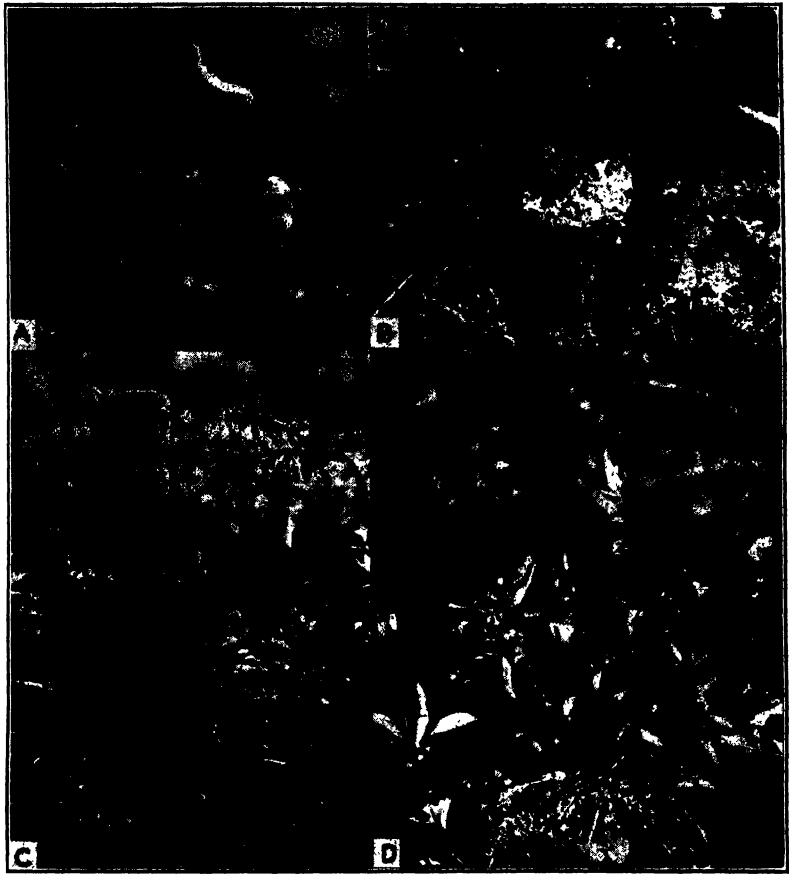


FIG. 1. *Cronartium coleosporoides*: A, B and C, spherical galls on *Pinus Banksiana*; D, telia on *Melampyrum lineare*.

Back in laboratory, this discovery was studied and compared with descriptions of *Cronartium* species given in Arthur's manual and no important difference was noted between our collection and the diagnosis of *C. coleosporoides* of western pines.

Since that time another abundant collection of this rust was made at Three-Rivers on the same plant and an earlier collection made many years ago by Professor Marie-Victorin in Lake St. John district was obtained from the Montreal Botanical Garden. More recently, part of a collection of a rust on *Rhinanthus borealis* from the north shore of St. Lawrence River some years ago, was

obtained from Professor E. Campagna. This plant, which also belongs to the Scrophulariaceae, supports telia having the same characters.

Before definite proof of the relation between the rust on *Melampyrum* and spherical gall of Jack Pine by direct inoculation from one to the other host, the author feels it advisable in the meantime to propose the extension of range of *C. coleosporioides* to eastern America and to add *Pinus Banksiana* to its list of aecial host.

SPECIMENS EXAMINED: Mycological Herbarium of the Division of Forest Pathology, Québec. On *Pinus Banksiana*: 687, June 1, 1934, 945, June 15, 1934, 2242, June 30, 1939, T. Barry, Oskelaneo River, Quebec; 3650, May 30, 1941, Lac Duparquet, Quebec, R. Pomerleau, 3701, June 2, 1941, Oskelaneo River, Quebec, R. Pomerleau; 3810, August 10, 1941, Godbout, Quebec, R. Pomerleau; 3815, June 1929, Ste. Anne de la Pocatière, Quebec, E. Campagna. On *Melampyrum lineare*: 3812, August 10, 1941, Godbout, Quebec, R. Pomerleau; 3925, August 23, 1941; Three-Rivers, Quebec, R. Pomerleau.

Herbarium of the Montreal Botanical Institute, on *Melampyrum lineare*: 16211, July 5, 1921, Lake St. John: "La Pipe," Quebec, Victorin.

Mycological Herbarium of the Agricultural School, Ste. Anne de la Pocatière, on *Rhinanthus borealis*: 8790 (3814 forest pathology, Quebec), July 27, 1935, Bergeronnes, Quebec, P. Gauthier.

DIVISION OF FOREST PATHOLOGY,  
DEPARTMENT OF LANDS AND FORESTS,  
QUEBEC

# STUDIES ON THE USTILAGINALES OF THE WORLD II

GEORGE L. ZUNDEL<sup>1</sup>

During the progress in the preparation of a manuscript on the Ustilaginales of the World, a large number of specimens have been received for study and examination. The following nine species were studied and are believed to be new undescribed species. Names are therefore proposed together with the following descriptions.

## *Ustilago caulicola* Zundel, sp. nov.

Sori covering the stems and occasionally the leaves with a reddish-brown, semi-powdery spore mass, 10 cm. or more long; spores chiefly subglobose to ellipsoidal, rarely globose, irregular, light reddish-brown to almost hyaline, chiefly 7–9  $\mu$  long (rarely 12.5  $\mu$  long), thick episore, spirally striate-echinulate.

Soris caulos et interdum folia tegentibus, massa sporarum rubro-brunnea et subpulverulenta, 10 cm. longis, sporis plerumque subglobosis vel ellipsoideis, rare globosis, irregularibus, dilute rubro-brunneis vel paene hyalinis, plerumque 7–9  $\mu$  longis (rare 12.5  $\mu$ ); crasso episporo, helice striato-echinulato.

Hab. in *Polygono campanulato* f. *fulvido* Hook.

On *Polygonum campanulatum* var. *fulvidum* Hook. f., Chiang K'ou, Fan Ching Shan, China. Fungi of Kweichow Province, No. 622. Coll. S. Y. Cheo, Oct. 1, 1931. Comm. Farlow Herbarium, Harvard University.

## *Ustilago epicampida* Zundel, sp. nov.

Sori in the ovaries, infecting all of them, showing through the glumes, ovate, 1–2 mm. long, spore-mass agglutinated; spores globose to broadly ellipsoidal, reddish-brown, variable in size and

<sup>1</sup> The Latin descriptions were written by Dr. E. Robert Dengler, Prof. of Classical Languages, The Pennsylvania State College, but were not added until the time of proof reading. The cooperation of Dr. Dengler is acknowledged but any errors in printing must be charged to the author.

shape, 5.5–10.5  $\mu$  diameter, smooth but granular, most spores have a characteristic large vacuole giving the appearance of a thick irregular episporium.

Sori omnia ovaria invadentibus, per glumas visis, ovatis, 1–2 mm. longis, massa sporarum agglutinata; sporis globosis vel late ellipsoideis, rubro-brunneis, in magnitudine et forma variantibus, 5.5–10.5 diam., levibus sed granularibus, sporis plerumque praebentibus magnum vacuolum quod est crasso et irregulari episporio simile.

Hab. in *Epicampide emersleyi* (Vassey), Hitchcock.

On *Epicampes emersleyi* (Vassey) Hitchcock (Muhlenbergia Emersleyi Vassey), Cerro Tancitaro (1100 ft.), Michoacán, Mexico. Coll. Wm. C. Leavenworth, Aug. 19, 1940. No. 718. Comm. U. S. Dept. of Agric., Mycological Collections.

### **Ustilago Underwoodii** Zundel, sp. nov.

*Ustilago hypodytes* (Schlecht.) Fries, p. p. Zundel in N. A. Flora 7: 978. 1939.

Sori as dark colored striae between the veins of the leaves, finally causing the leaves to become shredded, spore-mass, dark-colored, powdery; spores chiefly globose to subglobose, light olivaceous-brown, chiefly 4–6  $\mu$  diameter, smooth.

Sori fuscis et striatiformibus inter venas foliorum, tandem folia concidentibus, massa sporarum fusca, pulverulenta; sporis plerumque globosis vel subglobosis, dilute olivaceo-brunneis, 4–6  $\mu$  diam., levibus.

Hab. in *Panicum virgatum* L.

On *Panicum virgatum* L., Dew Drop, Staten Island, New York, coll. L. M. Underwood, June 1897 (type), also Richmond Valley, Richmond Co. (Staten Island), New York, June 16, 1917 by P. Wilson (Fungi within 100 miles of New York City, No. 541); George M. Reed, June 19, 1917 (No. 2332); L. A. Kolk, Sept. 19, 1939.

### **Sphacelotheca peruviana** Zundel, sp. nov.

Sori destroying the ovaries, globose but somewhat flattened at the two poles, hard, about 1 mm. diameter, covered by a delicate whitish membrane that disintegrates into delicate sterile cells that soon collapse, spore mass agglutinated; sterile cells tinted olivaceous-yellow with a thick almost hyaline episporium, globose to subglobose, often irregular, chiefly 7–8  $\mu$  diameter, delicate and soon

collapsing; spores globose to somewhat subglobose, chiefly regular, light reddish-brown, chiefly  $3-5\ \mu$  diameter, smooth, thick epispor.

Soris ovaria destruentibus, globosis sed aliquantum ad polos planis, duris, circa 1 mm. diam., membrana alba et delicata primo ambiente, deinde rupta in cellas delicatas sterilesque quae mox collabuntur, massa sporarum agglutinata; cellis sterilibus, olivaceo-flavis, episporo crasso, paene hyalino, globosis vel subglobosis, saepe irregularibus,  $7-8\ \mu$  diam., delicatis et mox decidentibus; sporis globosis vel subglobosis, plerumque regularibus, dilute rubro-brunneis,  $3-5\ \mu$  diam., levibus.

Hab. in *Sporobolus virginico* (L.) Kunth.

On *Sporobolus virginicus* (L.) Kunth., Paracas Bay, Near Pisco, Peru. Coll. H. O. Forbes, 1912, Comm. Agnes Chase (Type in U. S. D. A. Myc. Herb.).

· **Sphacelotheca utahensis** Zundel, sp. nov.

Sori in the ovaries, ovoid, about 1.5–2 mm. long, covered by a delicate membrane that disintegrates into sterile cells, spore mass dark brown, powdery; sterile cells globose to elongated, often irregular, hyaline  $7-14\ \mu$  long, smooth; spores globose to ellipsoidal, olivaceous brown, chiefly  $8.5-10.5\ \mu$  long, apparently smooth but indistinctly echinulate under oil immersion.

Soris in ovariis, ovoideis, circa 1.5–2 mm. longis, membrana delicata in cellas steriles decidente, massa sporarum fusco-brunnea, pulverulenta; cellis sterilibus, globosis vel elongatis, saepe irregularibus, brunneis, plerumque  $8.5-10.5\ \mu$  longis, apparenter levibus, sed, sub immersione ut dicunt olei visis, subechinulatis.

Hab. in *Sporobolus airoides* (Torr.) Torr.

On *Sporobolus airoides* (Torr.) Torr., Escalante Mountains, Garfield County, Utah (Montane Forest 7500). Coll. M. Stanton, June 20, 1932, No. 770. Comm. J. A. Stevenson.

**Sorosporium Chardonianum** Zundel, sp. nov.

Sori destroying the inflorescence, 6–12 cm. long, at first covered by a brown membrane which soon distintegrates exposing a dark brown, granular, spore mass intermixed with long brown shreds; spore balls globose to ellipsoidal, often irregular, dark brown, semi-opaque, semi-permanent, composed of many spores, chiefly  $35-70\ \mu$  long; spores globose to broadly ellipsoidal, often irregular or angular, olivaceous-brown, chiefly  $9-11\ \mu$  diameter, outer spores slightly verruculate, inner spores smooth.

Soris inflorescentiam destruentibus, 6–12 cm. longis, membrana brunnea primo ambiente, deinde dissoluta massam sporarum fusco-brunneam et granu-

larem pannulis longis brunneisque intermixtam praebente; massa sporarum globosa vel ellipsoidea, saepe irregulari, atro-brunnea, semi-translucida, semi-permanente, sporis numerosis, plerumque  $35-70\ \mu$  longis, globosis vel late ellipsoideis, saepe irregularibus vel angularibus, olicaveo-brunneis, plerumque  $9-11\ \mu$  diam., sporis externis leviter verruculatis, internis levibus.

Hab. in *Penniseto bambusiformi* (Tourn.) Hemsl.

On *Pennisetum bambusiforme* (Tourn.) Hemsl., Meridia, Venezuela. Coll. C. E. Chardon, December 4, 1936. Myc. Explor. Venezuela No. 1844 III.

**Tilletia Festuca-octoflorana** Zundel, sp. nov.

Sori in the ovaries, visible through the glumes, about 2 mm. long, 1 mm. wide, hard, olivaceous yellow; spores globose, subglobose to ellipsoidal, often irregular, with a halo around each spore, tinted, olivaceous-yellow to almost hyaline, chiefly  $16-21\ \mu$  diameter, spiny, spines about  $3.5\ \mu$  high; sterile cells or immature spores tinted olivaceous-yellow to almost hyaline, chiefly  $8-10.5\ \mu$  diameter, each one with a halo, smooth.

Soris in ovariis, per glumas visis, ca. 2 mm. longis, 1 mm. latis, duris, olivaceo-flavis; sporis globosis vel subglobosis vel ellipsoideis, saepe irregularibus, nimbo sporam quamque circumambulante, olivaceo-flavis vel paene hyalinis, plerumque  $16-21\ \mu$  diam., spinis ca.  $3.5\ \mu$  altis; cellis sterilibus vel sporis immaturis olivaceo-flavis vel paene hyalinis, plerumque  $8-10.5\ \mu$  diam., nimbo munitis, levibus.

Hab. in *Festuca octoflora* Walt.

On *Festuca octoflora* Walt., Tuscumbia, Miller Co., Missouri. Coll. Miss. Clara Fuhr. Comm. W. E. Maneval. Fall 1939.

**Entyloma Astor-sericeanum** Zundel, sp. nov.

Sori in the leaves, visible on both surfaces, flat, showing as inconspicuous yellowish spots,  $0.5-1$  mm. long, often coalescing and fusing into the surrounding green tissue without forming a definite margin; spores globose, regular, tinted yellow, chiefly  $12-18\ \mu$  diameter, smooth but granular, thick episporous.

Soris in foliis, in utraque superficie visis, planis, in maculas sub-flavas et haud conspicuas congestis,  $0.5-1$  mm. longis, saepe coalescentibus et in circumdatum folium sine margine fuis; sporis globosis, regularibus, flavis, plerumque  $12-18\ \mu$  diam., levibus sed granularibus, crasso episporo.

Hab. in *Aster sericeus* Vent.

On *Aster sericeus* Vent., sand plains, near Sauk City, Dana Co., Wisconsin (Type). Coll. H. C. Green, Sept. 20, 1940.

(?) **Entyloma Spragueanum** Zundel, sp. nov.

Sori on the leaves as elongated brown spots, slightly pustular, about 0.1–1 mm. long often coalescing; spores borne in rows between the veins, subglobose to ellipsoidal, clear olivaceous brown, chiefly 17.5–21  $\mu$  long, smooth, epispore 1.5–2.5  $\mu$  wide.

Soris in foliis, in maculis brunneis et elongatis, subpustularibus, ca. 0.1–1 mm. longis, saepe coalescentibus, in ordinibus inter venas visis, subglobosis vel ellipsoideis, pellucide olivaceo-brunneis, plerumque 17.5–21  $\mu$  longis, levibus, episporo 1.5–2.5  $\mu$  lato.

Hab. in *Poa pratensi* L.

On *Poa pratense* L., Taft siding, Traill Co., North Dakota.  
Coll. Dr. Roderick Sprague, May 3, 1940.

CONTRIBUTION DEPARTMENT OF BOTANY No. 132,  
PENNSYLVANIA STATE COLLEGE,  
STATE COLLEGE, PA.



## STUDIES IN THE GASTEROMYCETES V. A WHITE SIMBLUM

W. H. LONG

(WITH 2 FIGURES)

The winter of 1940-41 and the spring of 1941 were unusually wet for New Mexico, the state as a whole having two to three times the normal amount of precipitation. This produced very favorable conditions in the arid and semi-arid portions for the development of many species of saprophytic fungi, especially Gasteromycetes. These latter were abundant moreover in number of individual plants of a given species, particularly in the Lycoperdaceae and the Phallales.

Many specimens of *Simblum sphaerocephalum* have been found near Corona, New Mexico while the writer discovered a *white Simblum* growing near Albuquerque, N. M.

A truly white *Simblum* is a rarity in any country and none have been reported for North America. Occasionally albino specimens of normally red or yellow *Simblums* are found, especially of *S. sphaerocephalum*, but no consistently white plants of a *Simblum* were known to occur in this country until the discovery of the white plants here reported.

This white *Simblum* when fresh has a very pronounced amyl acetate odor, exactly like the yellow *S. texense*, previously described by the writer from Texas.<sup>1</sup> The plant also has several other characters common to *S. texense*. It is therefore made a variety of this species, since the writer does not consider the differences sufficient to warrant a new species.

***Simblum texense* var. *albidum* var. nov.**

*Sporophore* when young (egg stage) obovate to turbinate, 2-4 cm. across by 3-5 cm. tall with a strong radicating base having

<sup>1</sup>Long, W. H. The Phalloideae of Texas. Jour. Myc. 13: 102-114. 1907.



FIG. 1. *Simblum texense* var. *albidum*  $\times 1$ .

some roots 5 cm. long, woody brown to buffy brown,<sup>2</sup> originating 1–3 inches below the surface of the soil, when mature and elongated consisting of a volva, stipe and cap (receptacle). *Volva* circumscissile (FIG. 1), upper part borne on cap when plant elongates

<sup>2</sup> All colors used are after Ridgway, R. Color Standards and Color Nomenclature. 1912.

in the field, cup-like, tough, inflated, woody brown, furfuraceous with minute hyaline hyphae which bind grains of sand firmly to its outer surface. *Stipe* 4–8 cm. tall by 1–1.5 cm. thick, terete or flattened, often fluted or furrowed, hollow, white inside and out, walls composed of 2–3 layers of chambers, 1–2 mm. thick; *chambers* often opening either inwardly or outwardly, 1–2 layers of cells thick at top and 2–3 cells thick at base of stipe, each cell about 2 mm. in diameter by 4 mm. long, cells irregularly polygonal, 4–5 sided. *Cap or receptacle*, depressed-hemispheric to irregularly globose (FIG. 1, 2), 1–2 cm. across by 1–1½ cm. tall, composed of very irregular, more or less isodiametric or oblong meshes, 4–6 mm. in diameter, 12–24 in number, the outer row of meshes usually free from the stipe at its outer and lower margin, bars white, not transversely rugose (FIG. 2), just a thin membrane. *Gleba* when fresh greyish olive to buff olive, having a pleasant amyl acetate odor, becoming hard and black within 24 hours after plant elongates, deliquescing after rains and then foetid. *Spores* subglobose, oval to pyriform,  $2.8\text{--}3.5 \times 4.2\text{--}5.6$  microns, usual size  $3 \times 5$  microns, walls rather thick, hyaline, smooth.

**HABITAT:** Solitary in sandy-adobe alkaline soil in open grassy areas, in semi-arid regions.

**DISTRIBUTION:** New Mexico, Bernalillo County near Albuquerque, elevation 5000 feet, *W. H. Long*. June 1, 1941, 31 plants no. 9333. *Type*; June 9, 1941, 18 plants no. 9348. Sandoval County, 5½ miles west of San Ysidro on State Highway 44, elevation 6250 feet, *W. H. Long*. July 9, 1941, 1 plant no. 9378. A total of 50 plants.

A comparison of the description here given for *Simblum texense* var. *albidum* with that of *S. texense* will show the similarities as well as the differences between the two plants. The main difference is the white stipe and the white bars of the receptacle, not a trace of yellow is found in any of the 50 plants collected, also the color and surface of the eggs are not the same. *S. texense* has a yellowish white nearly smooth surface while the variety, *S. texense* var. *albidum* has a snuff brown, furfuraceous surface covered with grains of adhering sand. There are minor differences in the structure of the stipe and spore characters.

Figure 1, photographed after the specimen dried, shows a plant that elongated in the field, note that the cap does not show any generic characters, this is the usual condition of all plants that ex-

pand in the open; while figure 2 illustrates 4 plants that were collected in the egg stage and placed in a damp chamber until they elongated, these clearly show the *Simblum* characters. The large plant seen in the middle was photographed several days after it had elongated and had begun to dry out. This plant had a flattened, fluted stem consisting of 3 separate internal cylinders or tubes, each with its own individual walls but covered outside with a common wall as seen in the photograph.

This white *Simblum* was discovered within 100 yards of the writer's home where he has lived for 4 years, yet none were found till this year when the excessive precipitation kept the normally dry soil damp long enough for the plants to develop to maturity.

ALBUQUERQUE, NEW MEXICO

## CLAMP-CONNECTIONS IN THE TREMELLALES

G. W. MARTIN

There seems to be a general impression that clamp-connections, if not lacking, are at least of rare occurrence in the Tremellales. The presence of such structures in *Phleogena faginea* was one of the considerations which led Shear and Dodge (30) to suggest that that species might be regarded as a protogasteromycete, related to *Tulostoma*. Very recently, Buller (9), in his stimulating discussion of the diploidisation process, has suggested that in these forms "clamp-connections may not often be present." Justification for such a suggestion may be found in the fact that many of the best-known accounts of the groups involved make no mention of their occurrence, and the references that do occur are scattered, largely in taxonomic papers, frequently doubtful and sometimes inaccurate. Nevertheless, many such references occur and a partial summary may be useful at this time.

As early as 1872, the Tulasnes (31) pictured unmistakable clamp-connections in *Guepinia Peziza* (*Guepiniopsis tortus*) and *Pilacre Petersii* (*Phleogena faginea*) and what strongly suggest them in *Hypochnus purpureus* (*Helicobasidium purpureum*). Brefeld (8) also illustrated them in *Phleogena*, which, of course, is not gelatinous, but in none of the other tremellaceous forms which he studied, although they are actually present in most of these, and very conspicuous in some. Möller (22) showed them clearly in four Brazilian species. Of 129 species mentioned by Bourdot and Galzin (4) the presence of clamp-connections is noted in forty-two. Of fifteen valid species of *Tulasnella* and *Gloeotulasnella* recognized by Rogers (26), clamp-connections are reported as occurring regularly or occasionally in seven. Brasfield (5, 6, 7) records their occurrence in a number of species of the Dacrymycetaceae. Neuhoﬀ (23) has thus far treated fifteen species of Tremellaceae in his comprehensive monograph of the group: all are noted as having clamp-

connections. McGuire (13) recognized twenty-five species of *Sebacina*. Sixteen have clamp-connections; five apparently do not; in four they are not mentioned but it is possible that they occur in at least some of these. Since 1932 I have myself noted and illustrated such structures in a number of species. Numerous other references to them are to be found scattered through the literature.

In some species the clamp-connections are admittedly difficult to see. They are apt to be indistinct in forms with strongly agglutinated hyphae, such as those belonging to the section *Bourdotia* of *Sebacina*. In soft, gelatinous fructifications, such as those of certain of the *Dacrymycetaceae*, they are often distorted, especially in old basidiocarps; and even in the younger ones they may be more or less modified by the thick, gelatinous walls of the hyphae. Similar distortions occur in the genus *Auricularia*. On some hyphae they are entirely typical and may readily be seen in good mounts, but good mounts of the tough, rubbery pileus of the members of this genus are not easy to prepare. There remain, however, numerous species in which clamp-connections are easily observed in almost any mount.

The hyphae of many other tremellaceous fungi are often highly irregular and various kinds of enlargements as well as structures resembling false clamp-connections are commonly seen. Barnett (2) reported clamp-connections in four species, but unfortunately his drawings might be interpreted as representing false clamps. However, since unmistakable clamp-connections may be found in all four species, there is no reason to doubt the correctness of his report. Rogers (29) demonstrated the close relation between the clamp-connection at the base of the basidium and basidial proliferation in *Sebacina prolifera* and emphasized the striking similarity of this process with the development of clusters of asci through proliferation of the croziers. McGuire (13) pictures similar structures in other species of *Sebacina* and I have frequently seen them myself in various species of *Exidia* and *Tremella*.

It seems certain that some species never bear clamp-connections. The tough, fleshy species of *Sebacina*, represented by *S. incrustans* and *S. helvelloides*, lack them. Occasional references to their presence must be regarded as based upon inaccurate observation.

Closely related to such species are the members of the genus *Tremellodendron*, which also seem consistently to lack them (3). The very large genus *Septobasidium* (11) appears not to have them. Bourdot and Galzin (4, p. 7) report them as rarely present in *S. Bagliettioanum*, but this cannot be accepted without verification, especially as some species of *Septobasidium* are characterized by knobs on some of the hyphae which might easily be mistaken for clamp-connections. The species of *Septobasidium* are highly specialized parasites on scale insects, and it is perhaps significant that in *Eocronartium* and *Jola*, parasitic on mosses, and in the auriculariaceous parasite on *Cornus* and *Lonicera*, which is the unnamed perfect stage of *Glomerularia Corni* Peck, clamp-connections are also lacking. In *Sebacina* as a whole, as in most of the remaining genera, their presence seems to be the rule and their absence the exception.

In view of the chaotic taxonomy and involved synonymy of the Tremellales, any attempt to compile a complete list of species in which clamp-connections have been reported would be premature, especially as some authors report them as lacking in species in which others record them as present. Bourdot and Galzin, for example, report them as absent in *Phleogena faginea*, although they had been seen and illustrated by the Tulasnes, Brefeld, and Shear and Dodge, and are so conspicuous that they can scarcely be overlooked in a very casual examination. Such instances could be multiplied many times were it worth while. The following partial list, which includes many of the commoner species of temperate North America and such tropical American species as seem deserving of inclusion, may serve to give a fair idea of the relative abundance of clamp-connections in the order. Of the seventy-nine species listed, seventy-one have previously been reported as possessing clamp-connections. For the remaining eight, indicated in bold-faced type, this is, so far as I am aware, the first report.

#### TULASNELLACEAE

*Gloeotulasnella cystidiophora* Höhnelt & Lits. (4, 25, 26), *metachroa* Bourdot & Galzin (4, 26), *pinicola* (Bres.) Rogers (4, 26), ***traumatica*** (Bourdot & Galzin) Rogers (4, 26).

*Tulasnella allantospora* Wakef. & Pears. (26), *araneosa* Bourdot & Galzin (26), *bifrons* Bourdot & Galzin (4), *rutilans* (Johan-Ols.) Bres. (26).

## DACRYMYCETACEAE

*Arrhytidia enata* (Berk. & Curt.) Coker (5), *involuta* (Schw.) Coker (5, 6).

*Calocera macrospora* Brasf. (6).

*Ceracea canadensis* Jacks. & Mart. (21), *crustulina* Bourdot & Galzin (4, 7).

*Dacrymyces deliquescens* Duby (5), *Ellisii* Coker (5), *gangliiformis* Brasf. (7), *palmatus* (Schw.) Bres. (5), *punctiformis* Neuh. (5).

*Femsjonina luteo-alba* Fries (4, 5, 24).

*Guepiniopsis alpinus* (Tracy & Earle) Brasf. (5, 14), *chrysocomus* (Tul.) Brasf. (4, 5, 24), *tortus* (Fries) Pat. (5, 14).

## SIROBASIDIACEAE

*Sirobasidium Brefeldianum* Möll. (22), *sanguineum* Lag. & Pat. (10, 17).

## TREMELLACEAE

*Eichleriella Leveilliana* (Berk. & Curt.) Burt, *pulvinata* Coker, *spinulosa* (Berk. & Curt.) Burt (4).

*Exidia candida* Lloyd (10), *glandulosa* Fries (2, 4, 23, 24, 33), *nucleata* (Schw.) Burt (4, 23, 24, 33), *recisa* Fries (2, 4, 33), *saccharina* Fries (2, 23, 24, 33).

*Patouillardina cinerea* Bres. (16).

*Phlogiotis Helvelloides* (Fries) Mart. (23).

*Protohydnum cartilagineum* Möll.

*Sebacina adusta* Burt (13), *atra* McGuire (13), *calcea* (Pers.) Bres. (12, 13, 34), *calospora* Bourdot & Galzin (4, 13), *cinerea* Bres. (13, 27), *fugasissima* Bourdot & Galzin (13), *Galzinii* Bres. (13, 28), *molybdea* McGuire (13), *opalea* Bourdot & Galzin (13), *Pini* Jacks. & Mart. (13, 21), *podlachica* Bres. (13), *plumbescens*



Burt (13), *prolifera* Rogers (13, 29), *rimosa* Jacks. & Mart. (13, 21), *sublilacina* Mart. (13), *umbrina* Rogers (13, 28).

*Seismosarca alba* Lloyd, *hydrophora* Cooke (17).

*Stypella minor* Möll. (15).

*Tremella atrovirens* (Fries) Sacc., *aurantia* Schw. (27), *compacta* Möll. (22), *foliacea* Fries (4), *frondosa* Fries (4, 32), *lutescens* Fries (4, 22), *mesenterica* Fries (4, 32), *mycophaga* Mart. (21), *subanomala* Coker (27).

*Tremellodon gelatinosum* (Pers.) Fries (4).

#### HYALORIACEAE

*Hyaloria Pilacre* Möll. (19).

#### PHLEOGENACEAE

*Phleogena faginea* Link (8, 24, 30, 31).

#### AURICULARIACEAE

*Auricularia Auricula-Judae* (Fries) Schroet. (2), *delicata* (Fries) P. Henn., *mesenterica* Pers. (12), *polytricha* (Mont.) Sacc., *rosea* Burt.

*Cystobasidium sebaceum* Mart. & Couch (20).

*Helicobasidium candidum* Mart. (21).

*Helicogloea Lagerheimi* Pat. (1), *pinicola* (Bourdot & Galzin) Baker (4).

*Platyogloea fusco-atra* Jacks. & Mart. (21), *Peniophorae* Bourdot & Galzin (21).

*Stypinella orthobasidion* Möll. (22).

*Syzygospora alba* Mart. (18).

#### SUMMARY

Seventy-nine species of tremellaceous fungi, all occurring in the western hemisphere and representing all families except the Septobasidiaceae, are recorded as possessing clamp-connections. Such structures have previously been noted in seventy-one of the species listed.

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## NON-VALIDITY OF THE GENUS ASPOROMYCES<sup>1</sup>

E. M. MRAK, H. J. PIIAFF AND B. L. SMITH

The imperfect yeast genus *Asporomyces* includes a single species, *A. asporus* described by Chaborski (1919). The essential points of the generic description given by Chaborski are as follows: The cells attempt conjugation by the formation of abortive conjugation tubes although ascospores are not formed. The species is characterized by fermenting glucose, sucrose, raffinose, maltose and inulin but not galactose, lactose, dextrin or soluble starch. This organism unfortunately was lost and hence has not been available for comparison with subsequently isolated cultures. In view of this Ciferri and Redaelli (1929) tentatively retained the genus in their treatment of the family Torulopsidaceae. They stated, "We reserve our final judgment until such time as we shall have been able to study this species directly in culture. Until then, we think it best to include it among the Torulopsidaceae, subfamily Torulopsidae because normally it has no mycelium." Lodder (1934) also retained the genus tentatively and made provision for it in her key of genera of the subfamily Torulopsidae as follows:

"Auf Gorodkowa-agar Bildung von eigentümlichen Schläuchen, den Kopulationsausläufern der *Zygosaccharomyces*-arten sehr ähnlich ..... *Asporomyces* Chaborski."

Mrak and McClung (1940) isolated two nonsporulating yeasts forming abortive conjugation tubes, and, in accordance with the key of Lodder, included them in the genus *Asporomyces*. Since the specific characteristics differed from those of *A. asporus* the cultures were described as *A. uvae* a new species. A culture of this organism, sent to the "Centraalbureau voor Schimmelcultures," was examined by Dr. T. Hof who subsequently expressed the view, in a personal communication, that the culture is similar to

<sup>1</sup> Part of non-technical assistance supplied by W. P. A. Official Project 65-1-98-91—Unit B-5.

*Torulopsis pulcherrima* and should not be included in the genus *Asporomyces*. This view is supported by the observations of Windisch (1938) and Porchet (1938) who found that certain strains of *T. pulcherrima* produce abortive conjugation tubes and at times even form sterile dumbbells. The writers have also made similar observations with strains of *T. pulcherrima*. If the key given by Lodder was followed in the classification of these strains, *T. pulcherrima* would fall into the genus *Asporomyces* and if the genus is acceptable should be included therein. On the other hand, if the formation of abortive conjugation tubes is widespread in the imperfect yeasts, the genus *Asporomyces* can hardly be considered acceptable and its use should be discontinued.

In order to determine the extent of abortive tube formation in the imperfect yeasts several cultures were inoculated on carrot, potato and beet wedges and Gorodkova agar slants for periodic examination. Those forming conjugation tubes or dumbbells or both were: *Torulopsis pulcherrima* (8 cultures); *T. lipofera*, *T. californicus*, *T. luteola*, *T. kefir* (2 cultures); *T. dattila*, *T. utilis*, *T. dactylifera*, *Torula rosea* (American Type Culture Collection No. 4055) and *Candida tropicalis*. Those failing to form tubes or dumbbells after 6 months were, *Torulopsis pulcherrima* (8 cultures), *T. fermentans*, *T. lactosa*, *T. alactosa*, *Torula monosa* (*Candida monosa*) and *Rhodotorula rubra*.

Sporulating yeasts have also been observed to form abortive conjugation tubes occasionally on various sporulation media. A few examples are: *Zygosaccharomyces* sp. R. (from Japan), on potato, *Z. priorianus* on Gorodkova agar, *Z. mandshuricus* on beet, *Debaryomyces Guilliermondii* (2 cultures) on beet and potato, *Saccharomyces* (Jerez strain, 4 cultures) on potato, *Pichia* sp. and *Schwanniomyces occidentalis* (2 cultures) on potato and beet. These organisms could easily have been classified as species of *Asporomyces* since in most instances sporulation was sparse or absent on the medium on which abortive conjugation tubes were observed.

The observations discussed above indicate that the formation of abortive conjugation tubes is not restricted to a single genus or family of yeast. It has been seen frequently, although it does not appear to occur with any regularity or under a given set of condi-

tions indicating that tube formation is not a reliable morphological character. In view of these circumstances it is concluded that abortive tube formation cannot be used to differentiate a genus and therefore the genus *Asporomyces* is no longer acceptable even in a tentative manner. *Asporomyces uvae* should be emended to *Torulopsis pulcherrima* as suggested by Hof. The true identity of *Asporomyces asporus* will probably remain in doubt although its fermentation characters are similar to those of *T. californicus*.

The key for the subfamily Torulopsidoideae as given by Lodder (1934) must be revised to omit the genus *Asporomyces* as given below:

**KEY FOR THE GENERA OF THE SUBFAMILY TORULOPSIDOIDEAE**

1. a. Cells predominantly apiculate, bipolar budding.....*Kloeckera* Janke  
b. Cells predominantly triangular, budding at the corners  
*Trigonopsis* Schachner  
c. Cells predominantly flask shaped, budding frequently on a broad base  
*Pityrosporum* Sabouraud  
d. Cells different, mostly spherical, oval or cylindrical ..... (2)
2. a. No pellicle on liquid wort or a moist, somewhat slimy pellicle after prolonged standing .....*Torulopsis* Berlese  
b. In wort a dull dry pellicle forms rapidly ..... (3)
3. a. Cells frequently cylindrical. Reproduction by budding, the buds are not separated from the mother cell by fission  
*Mycoderma* Persoon emend. Leberle  
b. Cells polymorphic, reproduction by budding. The buds are frequently separated from the mother cell by fission....*Schizoblastosporion* Ciferri

UNIV. OF CALIFORNIA  
BERKELEY

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# PTYCHOGASTER CUBENSIS, A WOOD-DECAYING FUNGUS OF SOUTHERN OAKS AND WAXMYRTLE

ROSS W. DAVIDSON, W. A. CAMPBELL, AND GEORGE F. WEBER

(WITH 3 FIGURES)

Routine isolations from decay in living hardwoods occasionally reveal the presence of fungi not previously known to invade living trees. The decay fungi may be species that fruit commonly on old logs or stumps, as *Stereum gausapatum* Fries in oaks and *Polyporus glomeratus* Peck in maple, or little known fungi such as *Poria Andersonii* (Ellis & Ev.) Neum. and *Polyporus compactus* Overh. in oaks. Identification of cultures of the former group do not present such a difficult problem since it is usually possible to obtain sporophore cultures for comparison, but cultures of the latter group are much more difficult to identify. However, the identity of an isolate is sometimes suggested through comparisons of some microscopic features of the culture with described characteristics of sporophores. For instance, Overholts (6) described the context of *P. compactus* as composed largely of hyaline chlamydospores, whereas the most distinguishing characteristic of cultures of this fungus are the conspicuous masses of similar chlamydospores. The identities of cultures of *Poria Andersonii* and *Polyporus glomeratus* were first suspected by the presence of abundant hyphal setae which are conspicuous in sporophores of these species (1).

In 1935 Hepting (2) referred to 60 unidentified isolates obtained in a decay study in Mississippi Delta hardwoods. Among these was a culture from decay in the heartwood of willow oak (*Quercus phellos* L.) that formed abundant brown conidia. Another culture of what appeared to be the same fungus species was isolated in 1938 from heartwood of a living water oak (*Q. nigra* L.) from Florida. At that time a careful search of the literature disclosed the fact that brown conidia described by Patouillard (7, p. 133)

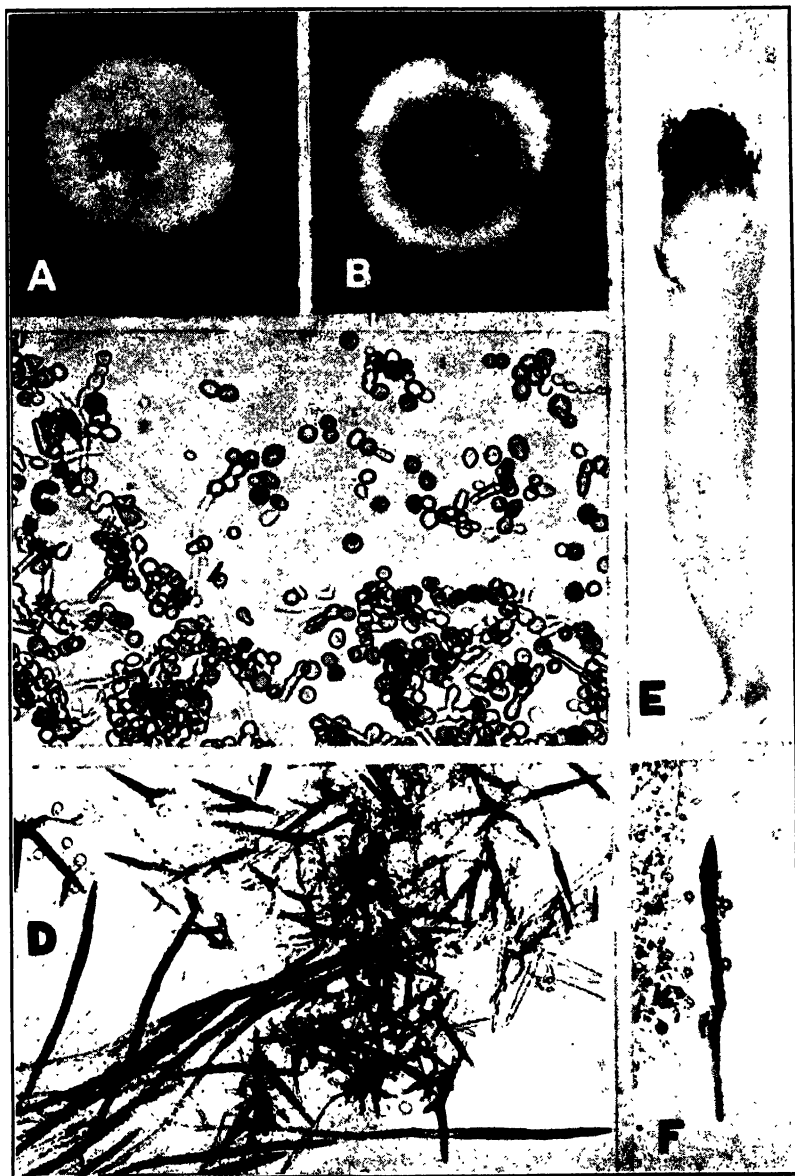


FIG. 1. A-E, *Ptychogaster cubensis* Pat. from southern hosts: A, 14-day-old culture from oak; B, 14-day-old culture from southern waxmyrtle; C, photomicrograph of conidia from a pure culture,  $\times 250$ ; D, photomicrograph of large and small setae from a pure culture,  $\times 250$ ; E, spore mass formed at upper margin of malt agar slant-culture; F, setal-hypha and conidia from *Polyporus Rickii* (Pat.) Sacc. & Trott. collected in Peru.



for the fungus *Ptychogaster cubensis* Pat. were very similar to those in cultures of the fungus from oak heartwood from Louisiana and Florida.

The following year (1939) a fungus composed of masses of brown conidia was collected on the trunk of turkey oak (*Quercus Catesbaei* Michx.) and on the stump of the *Q. nigra* from which the Florida culture had been obtained, and what seemed to be the same fungus was found in Florida on numerous living stems of southern waxmyrtle (*Myrica cerifera* L.) in association with dead branch stubs or wounds and decay. Cultures from decay back of these conidial masses indicated the fungi on southern waxmyrtle and oak to be the same as the one previously isolated from oak heartwood.

In January 1941 this same conidial stage was again collected in Florida on a living sand live oak tree (*Quercus virginiana geminata* (Small) Sarg.) and as a fungus of this type has not been reported from North America before and, since it seemed to be of importance as the cause of decay in living trees, a preliminary account is presented at this time.

#### COMPARISON WITH DESCRIPTIONS AND HERBARIUM SPECIMENS OF PTYCHOGASTER

In general the fungus from Florida and Louisiana appears to be the same as *Ptychogaster cubensis* Pat. that was described from Cuba in 1896 (7) and the conidial stage of *Xanthochrous Rickii* Pat. collected by Rick in Brazil (8, p. 6) and later referred to *Polyporus Rickii* (Pat.) Sacc. & Trott. (10, p. 270). However, Patouillard described *P. cubensis* as having a somewhat more compact structure than is shown in the Florida specimens.

In 1915 Lloyd (3) called attention to the similarity of *Polyporus Rickii* to *P. glomeratus*, presumably from a similarity in appearance and in presence of imbedded setae in both, and suggested *Ptychogaster cubensis* as being the same thing. Lloyd further states, "I hardly feel that the subject is much cleared up by the publication of such species." However, in 1917 (4) he described *Ptychogaster lucidus* from a specimen collected by Rev. C. Torrend in Brazil. It was growing from or in very close association with a

normal sporophore of *Polyporus lucidus*. In compact structure and spore character the conidial part of this specimen is very similar to that described for *P. cubensis*.

#### SPECIMENS EXAMINED

The Mycological Collections of the Bureau of Plant Industry, U. S. Department of Agriculture, contain a number of *Ptychogaster* specimens among which are those mentioned by Lloyd:<sup>1</sup>

*Polyporus Rickii* Pat. 133 (C.G.L. Cat. No. 18854) "ex type." This is only a fragment of rather compact tissue containing a few conidia similar to *P. cubensis* and large setal hyphae but no evidence of pores.

*Ptychogaster Fici* Pat. (C.G.L. Cat. No. 58824) "ex type." There is no other data with this specimen but it has conidia similar to *P. cubensis*.

"*Ptychogaster lucidus* Lloyd." "Type" from Rev. C. Torrend, Bahia, Brazil (C.G.L. Cat. No. 55501). This specimen consisted of what appears to be a distorted sporophore of *P. lucidus* and a globose *Ptychogaster* with compact zoned structure similar to that described by Patouillard for *P. cubensis* and abundant brown conidia and large setal hyphae. These two specimens are not now connected. There seem to be very few if any spores of the *Ptychogaster* in the tissue of the *Polyporus*.

A most interesting specimen was one identified as *Polyporus Rickii*, collected at Lima, Peru, on a fruit tree October 13, 1917, by J. R. Weir (C.G.L. Cat. No. 18866 and No. 9367 ex. herb. J. R. Weir). This specimen consists of a somewhat globose mass of context tissue with a radiating zonate structure and filled with abundant conidia similar to those described for *Ptychogaster cubensis*. From the under side of the outer margin and arising directly from the mass of context tissue are coarse brown pores about 1 cm. in length. Conspicuous, large, brown setal hyphae are present in the tramal tissue of these pores (FIG. 1, F).

*Ptychogaster* sp. (C.G.L. Cat. No. 55504). Collected by L. J. K. Brace, Nassau, Bahamas. This is a *Polyporus* with imbricate

<sup>1</sup> The authors acknowledge the assistance of J. A. Stevenson in examination of valuable specimens in the C. G. Lloyd Herbarium and in the Mycological Collections of the Bureau of Plant Industry.

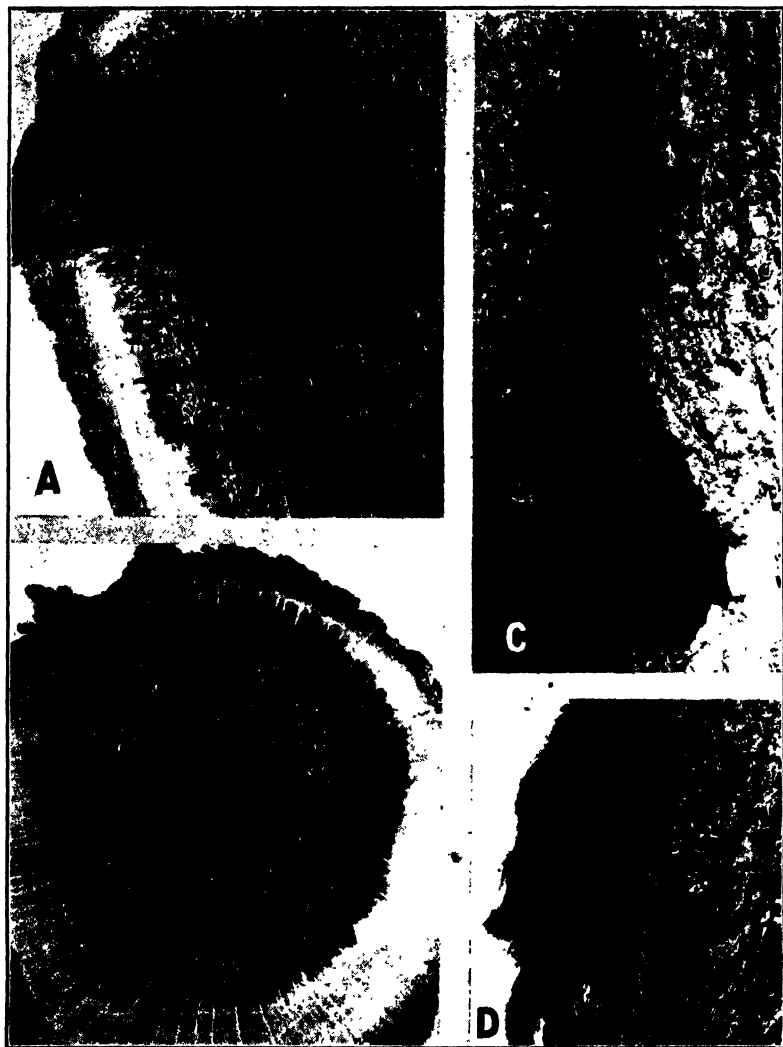


FIG. 2. *A-D*, *Ptychogaster cubensis* Pat. on southern oaks: *A*, longitudinal section through a stem showing decay advancing into sapwood area and sterile mass of fungus tissue formed at a branch stub; *B*, cross section of the same stem; *C* and *D*, conidial fruiting masses.

pilei, 5 inches broad and about 1 inch thick at base to  $\frac{1}{8}$  inch thick at margin, surface covered with dark red-brown ("chestnut" to "russett"<sup>2</sup>) dusty mass of conidia; context corky, light brown

<sup>2</sup> All colors in quotation marks are from Ridgway (9).

("clay color"); pores mostly 1 cm. long but much shorter at margin of pilei; mostly filled with masses of light brown, broadly ovoid ( $7 \times 5 \mu$ ) basidiospores, mouths of pores closed by a layer of the dark red-brown conidia. Freehand sections disclosed the context tissue also contained numerous hyaline to light brown conidia interspersed with the brown mycelium. Except for their lighter color the context conidia were similar to those on the surface of the sporophore. The hymenium contained four-spored globose basidia and a few small setae projecting about  $25 \mu$ . Large setal hyphae were abundant in the tramal tissue with their points sometimes projecting through the hymenium at an acute angle.

This and the Weir specimen from Lima, Peru, are somewhat similar although this Brace specimen is in much better condition and, as indicated by presence of basidia and spores, was probably in active sporulating condition when collected. The pores of the Peru specimen contained what appeared to be a few light brown basidiospores but no basidia. These were the only two specimens seen that definitely indicate that a conidial fungus similar to that described for *Ptychogaster cubensis* has a basidial stage belonging to the genus *Polyporus*.

*Ptychogaster* sp. (C.G.L. Cat. No. 55503) collected by L. J. K. Brace, Nassau, Bahamas, 1916. The specimen is now just a loose mass of dark brown spores, but a letter from Brace states, "Like a light brown cake in its rounded top shape, about 4 inches wide and 2 inches high growing on side of citrus tree which is decaying . . . golden orange, reddish. . . ."

*Ptychogaster* sp. (C.G.L. Cat. No. 25150 and No. 23). From S. R. Bose, Calcutta, India. This specimen was fairly compact and with radiating structure but is now broken up. A few setal hyphae were found in the mass of spores.

*Ptychogaster* sp. (C.G.L. Cat. No. 19990 and No. 11). From S. R. Bose, Calcutta, India. "Growing on side of tree trunk. Hymenial surface yellow sometimes dark yellow. General color deep brown with yellow tinge on upper surface." This specimen is rather compact with no pores or hymenial surface evident at this time.

*Ptychogaster* sp. (C.G.L. Cat. No. 50545 and No. 25144). From J. Rick, Brazil. This specimen has a fairly compact radiating structure.

*Ptychogaster* sp. (C. L. Shear No. 835) from Waipio ridge, Oahu, T. H., on stem of *Acacia koa* A. Gray, March 3, 1928.

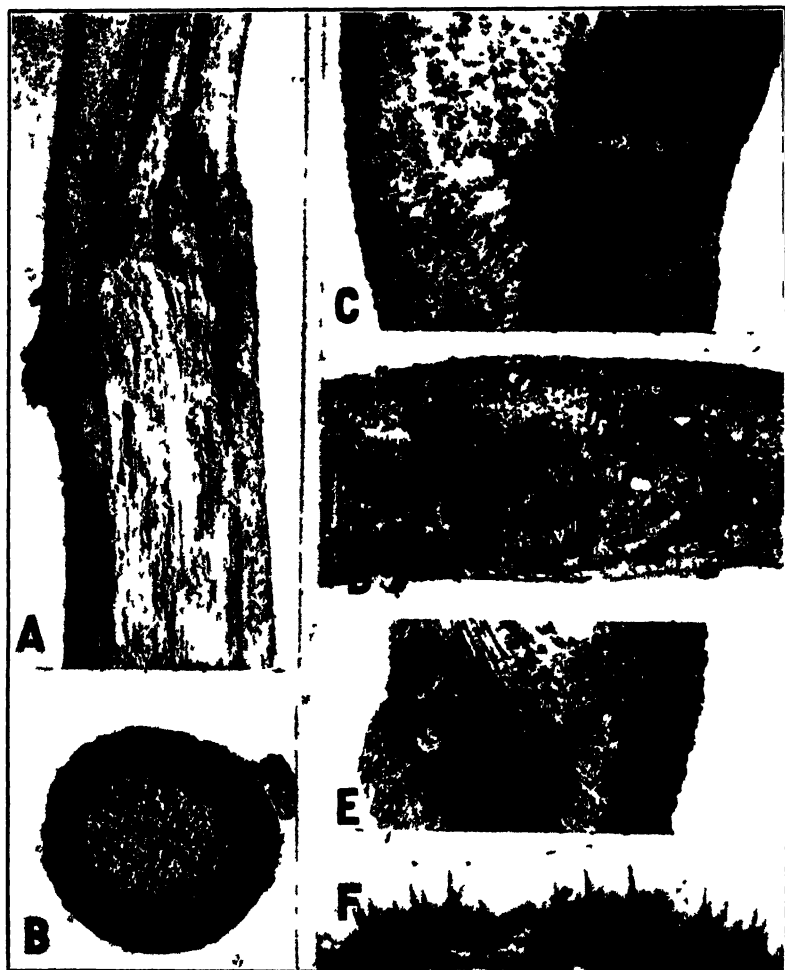


FIG. 3. A-F, *Ptychogaster cubensis* Pat on southern waxmyrtle (*Myrica cerifera* L.): A and B, sections through infected stems showing decay; C, conidial fruiting at the base of a dead branch; D, layer of fungus growth over old injury; E, hard sterile mass formed on stem at branch stub trace; F, photomicrograph of section from fungus layer in D showing setae projecting from surface.

This specimen consists of a loose mass of spores and fungus strands which is similar to specimens from Florida.

*Ptychogaster* sp. Collected by V. K. Charles in Haiti, March 1921, on very large trunk of living *Tamarindus indica* L. Miss Charles states that this was a large powdery mass of spores, 1 to 2 feet across, about 8 to 10 feet up on the trunk.

*Ptychogaster* sp. (Plants of Haiti No. 11439) collected by E. C. and G. M. Leonard, January 1, 1929, from base of tree near shore, vicinity of La Vallée, Tortue Island, Haiti. This specimen consists of a compact, radial, zonate mass of hyphal strands and spores with hard covering of mycelial tissue. Setal hyphae were also observed in microscope mounts.

All of the above specimens contain conidia that are similar in size and color to those of the fungus from Florida and Louisiana, but some of them are more compact in structure and several have a firm covering layer not observed for any of the Florida specimens.

The presence of *Polyporus lucidus* attached to one specimen studied by Lloyd is probably the result of a close association of two organisms, but the *Polyporus* specimens from Peru and Bahamas and possibly the type of *P. Rickii* from Brazil, of which only a fragment was seen, indicate that the basidial stage of *Ptychogaster cubensis*-like conidial fungi belongs in the genus *Polyporus*.

#### HOST RELATIONSHIP

Study and comparison of cultures from decay in oaks and from decay in southern waxmyrtle indicate that the fungus from these unrelated hosts belongs to the same species. It is reasonable to expect it to occur in numerous other hosts as indicated from collection records with some of the herbarium specimens already referred to.

In the few oak trees examined it was causing extensive white to yellow-brown decay in the heartwood and in at least one of these trees it was advancing into the sapwood (FIG. 2, *A* and *B*). In southern waxmyrtle it was causing white decay in the central area of the stems (FIG. 3, *B*), extending upward from 5 to 18 inches from the entrance point and downward about the same distance. About 24 infected stems were examined, ranging in diameter from

1½ to 2½ inches. Since these stems did not appear to have heartwood the fungus is probably parasitic, working upward through the older sapwood area and encroaching slowly on the outer sapwood (FIG. 3, A). Some of the infected stems had died but whether the decay fungus was responsible for this condition could not be determined. A number of the stems had enlarged dead areas at or near the point of infection. Infections were centered at dead branch stubs or injuries.

The conidial fruiting developed at branch stubs (FIG. 3, C), wounds, or directly through the bark of some of the dead stems (FIG. 2, C and D). The fungus had formed hard layers or masses of old mycelial tissue at many of the stubs (FIG. 2, A) and wound areas (FIG. 3, D). Several were hard, irregular, rough, thick knots of tissue (FIG. 3, E), resembling small sterile conks of *Polyporus glomeratus* or *Poria obliqua*, and a number were more uniform layers 1 to 2 mm. thick with many brown setae projecting from the surface (FIG. 3, F). The latter suggested old sporophores of *Hymenochaete* but there was no indication of a basidial layer. Brown conidia were sometimes present on or imbedded in these layers of fungus material.

In 1919 Merrill (5) reported collecting *Ptychogaster cubensis* in Cuba on "base of trunks" but names of the hosts were not given.

#### CONIDIAL FRUITING ON STEMS

There is great variation in extent and appearance of the conidial stage formed under natural conditions. On the oaks, the conidial mass was quite large (FIG. 2, C and D) but on southern wax-myrtle they were usually small (FIG. 3, C). Some of the conidial masses were fairly compact but most of them were loose and somewhat plumose. All of the larger conspicuous masses consisted of long strands of hyphae radiating outward and downward from a central point of attachment and surrounded with a mass of powdery, dark red-brown spores. The strands of hyphae were usually from ½ to 1½ inches in length and extended through the bark from the wood surface. None of the spore masses had any noticeable covering at the time they were examined in the laboratory.

The spores appear to form in chains from the radiating strands of hyphae, are variable in shape but usually globose, 8–13  $\mu$  in diameter, thick walled, and dark brown. Short or long setal hyphae are present in the mass of spores and hyphae.

#### THE FUNGUS IN CULTURE

Cultures of *Ptychogaster cubensis* were obtained from decayed wood and from hyphal strands of the conidial fruiting body. Attempts to germinate conidia were unsuccessful. Growth rate of several isolates was recorded for various constant temperatures in the dark. There was no growth at 10°, good growth at 30°, and no growth at 40° C. Inoculum held at 10° C. for 18 days grew when it was returned to room temperature but inoculum held at 40° C. for 18 days failed to grow when returned to room temperature.

*Technical description:* Growth slow, forming in 14 days a mat 2.5–5 cm. in diameter; <sup>3</sup> mat at first white, moderately raised, loose-cottony becoming in 7 to 14 days "cream color," "cinnamon buff," "gray buff" to as dark as "buckthorn brown" at the center or over most of mat and with a narrow or wide white marginal zone (FIG. 1, *A* and *B*); mat color dependent upon intensity of light and in weak illumination some isolations remain white or become only slightly "cream color" around the inoculum in 14 days; colored center somewhat compacted, often appressed, usually glistening from innumerable fine guttation drops; entire mat fragile, mostly azonate; margin proper white, even, cottony.

Test-tube cultures at first entirely white becoming in diffused light irregularly "cinnamon buff" and "buckthorn brown" on upper part of slant and on agar cylinder; setal hyphae form in abundance next to glass and appear as fine brown streaks that can be seen with the naked eye; cultures in dark remain white and if undisturbed for 4–6 weeks most isolates form a typical brown *Ptychogaster* mass of spores on upper part of slant (FIG. 1, *E*).

<sup>3</sup> Description based on mats grown in diffused light on 2 per cent Difco malt agar at room temperature of about 25° C.



Staining hyphae thin-walled  $1-5\ \mu$  in diameter, with cross-walls but without clamps; non-staining yellowish hyphae found in brown portions of mat in connection with conidia formation; conidia very abundant, with staining content when immature, becoming brown when mature, often formed in chains, individual conidia globose, ovoid or irregular  $5-10\ \mu$  in diameter (FIG. 1, C); setal hyphae abundant in some cultures, less common in others, opaque  $5-12\ \mu$  in diameter; irregular short setae also common (FIG. 1, D).

#### SUMMARY AND CONCLUSIONS

A fungus tentatively identified as *Ptychogaster cubensis* Pat. was isolated from heartwood decay in *Quercus phellos* L. from Louisiana and *Q. nigra* L. and *Q. Catesbaei* Michx. from Florida and from decay in numerous living stems of *Myrica cerifera* L. in Florida. The conidial stage was collected on trunks of dead *Q. Catesbaei*, *Q. nigra*, and *M. cerifera*, and at branch stubs and injuries on living trunks of *M. cerifera* and *Q. virginiana geminata* (Small) Sarg.

Numerous herbarium specimens of *Ptychogaster* were examined which contained conidia of the same size and color as the fungus from Florida and Louisiana. All of these seem referable to *Ptychogaster cubensis* Pat. and were from Brazil, Peru, Territory of Hawaii, India, Haiti, and Bahamas. Whether or not these specimens represent one or several species will depend on comparison of cultures from various hosts in the above localities. The herbarium specimens from the Bahamas and Peru have pores developed in close association with the conidia, which indicates that the basidial stage of this type of decay fungus belongs to the genus *Polyporus*.

Cultures from the Florida and Louisiana specimens have been studied and described in detail. Conidia and setal hyphae similar to those formed in nature are abundant in the cultures studied.

BUREAU OF PLANT INDUSTRY, U. S. DEPARTMENT  
OF AGRICULTURE, WASHINGTON, D. C.  
AND  
FLORIDA AGRICULTURAL EXPERIMENT STATION,  
GAINESVILLE, FLORIDA

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# STUDIES IN THE GENUS HELOTIUM.

## I. A REVIEW OF THE SPECIES DESCRIBED BY PECK

W. LAWRENCE WHITE<sup>1</sup>

(WITH 16 FIGURES)

Not since Rehm some fifty years ago treated the Discomycetes of Germany, Austria, and Switzerland for Rabenhorst's Kryptogamen-Flora, and never for any part of the world other than Europe, has there been any attempt at a monograph of *Helotium* or even of any very closely allied genera. That genus (including *Phialea*) now embraces several hundred so-called species, many of them known only from the original description. Because the early types have not been restudied and the descriptions organized into a usable system—in general, because of a lack of literature for identification work—the non-specialist of today generally neglects even to collect such forms, for once having done so it is impossible to attach to them a name under which they may be preserved and studied. In the present writing, which is intended to represent a preliminary contribution toward a monograph of the genus, an effort is made to amplify Peck's original descriptions and to bring together in one paper all of the records, both of literature and herbarium specimens, that can be located representing species described by him and belonging in *Helotium*. An exception is *H. gracile*, a synonym for *H. scutula*, for which space is not available for as detailed a treatment as is given the less common forms. Taking into account the fact that Peck's names are now of some seventy to eighty years standing, one is much impressed at the slight extent to which they have come into circulation. The scantiness of the records is to be interpreted as an index to the amount of collecting and the extent of past work on fungi of this group, rather than to their actual occurrence and geographic distribution.

<sup>1</sup> Contributions from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 202.

During the forty-eight years, 1867 to 1915—mostly for the relatively brief period of 1874 to 1890—of his official connection with the New York State Museum, Peck described as new under the generic name *Helotium*, eighteen species. Of this number, eight will fall into the genus as it is understood at the present time and the remaining ten should be excluded. Of those eight species properly placed by Peck, his specific names remain valid for five. Of those excluded, one, *H. macrosporum*, has recently been transferred to its proper taxonomic position by Miss Kanouse with Peck's specific name valid; another, *H. thujinum*, appears in Seaver's North American Cup-Fungi as a synonym of an old European operculate species; two are known to the writer only from Peck's material; and six are here for the first time referred to synonymy under old, well-known European names. Peck's conception of *Helotium* was so broad that he erred less frequently in placing true members of that genus elsewhere. He did, however, describe three species in *Peziza*, one of which was transferred to *Helotium* by Saccardo, while the other two are transferred in the present paper; also, near the end of his career, in an apparent attempt to follow the Saccardoian system he described a *Phialea anomala* which the writer recently has reduced to synonymy under *Rutstroemia longipes*. Condensing certain of the foregoing data: out of a total of twenty-two species described by Peck—those he placed in *Helotium* plus those he should have placed there—eleven of his specific names may stand for the present, ten are out because of priority, and one is a homonym. In addition to his "new species" Peck listed a total of seven old European forms which he found in New York State. These are appended for the sake of completeness; all are of common occurrence in the state.

Peck's herbarium is excellently preserved at Albany. Type material of all the species of the present paper is there and in most cases the specimens are very ample for study. In some instances, however, where Peck collected a species more than once, difficulty was experienced in determining just which packet represented the type; and even more difficult was the problem of knowing which specimens at Albany were represented by the portions of specimens found in other herbaria.

Only material actually studied is cited, and the herbarium in which the specimen examined is located is designated by an abbreviation in parentheses. The abbreviations used are those published by Dr. J. Lanjouw of the Commission for Urgent Taxonomic Needs of the International Botanical Congresses (*Chronica Botanica* 5: 142-150. 1939), with an additional letter in some instances to denote herbarium subdivisions. They are as follows: CUP = General Herbarium of the Department of Plant Pathology, Cornell University; CUP-D = Durand Herbarium in the same department; FH = Farlow Herbarium; FH-E = Ellis Herbarium in the Farlow Herbarium; FH-H = von Höhnelt Herbarium in the Farlow Herbarium; FH-P = Patouillard Herbarium in the Farlow Herbarium; NY = New York Botanical Garden; NYS = New York State Museum; OTB = Division of Botany, Central Experimental Farm, Ottawa.

*HELOTIUM ALBUMINUM* (Cooke & Peck) Saccardo, Syll. Fung. 8: 214. 1889.

*Peziza albumina* Cooke & Peck, in Peck, Ann. Rep. N. Y. State Mus. 26 (1872): 81. (June) 1874; Cooke, Bull. Buffalo Soc. Nat. Sci. 2: 294. 1875; Cooke, *Grevillea* 4: 132. *pl.* 65, *fig.* 283. 1876; Peck, Bull. Buffalo Soc. 4: 219 (155). 1883.

*Calycina albumina* (Cooke & Peck) Kuntze, Rev. Gen. Pl. 3<sup>2</sup>: 448. 1898.

#### FIG. 5

**Apothecia** solitary or more often gregarious, sometimes crowded and showing a slight tendency to become confluent, pale yellow when dry and more or less concolorous throughout; **stipe** papilla-like or slender, cylindric, and distinct; **disc** opening by a pore, expanding and becoming nearly plane, in the dried condition thin, rather deeply concave, often slightly contorted, reaching a diameter of 0.4-0.6 mm., rarely up to 0.9 mm.; **receptacle** well elevated above the substratum, entirely free even when the stipe is nearly lacking, when dry cream-colored to buff or pale ochraceous, under the lower powers of the microscope appearing very finely striolate or white-puberulent; **margin** thin, turned inward in dried material so as to partially obscure the hymenium, circular or lobed; **hymenium** waxy in dried material, concolorous with receptacle or yellowish, often varying toward citron; **paraphyses** simple, scarcely or not

at all enlarged at apex, about  $2\ \mu$  diam.; asci cylindric above; subtruncate, slightly narrowed below to a broad basal portion,  $42\text{--}55 \times 5\ \mu$ ; **ascospores** biseriate, 1-celled, allantoid,  $7\text{--}9 \times 1.2\text{--}1.8\ \mu$ .

On dead wood and bark of frondose trees, recorded by collectors on quince?, *Acer* sp., and undetermined species; in one case an erumpent pyrenomycetous fungus is present and many apothecia very definitely are growing from its stromata.

Previously recorded only from New York on the basis of Peck's material. Specimens have been examined from New York, Michigan, Oregon, and Ontario.

*Material examined: New York:* The collection data on the Peck packets found in the various herbaria has been so inadequately and even incorrectly preserved that it is now not possible to determine with absolute certainty whether they represent one or more than one original collection, at least not without bringing together all portions in the same laboratory for careful comparison. Certainly they represent only one species. Each is cited as a separate collection with full data as it now appears on the label. 292. *Peziza albumina* C. & P. On wood. N. Greenbush. Oct. *Type.* (NYS); Albany, N. Y. Oct. C. H. Peck (292). *Type.* (CUP-D 3739); On wood. North Greenbush, N. Y. Oct. Dr. Peck. (CUP-D 5612); Greenbush, N. Y. (NY); On *Acer*. Clyde. Feb. 1888. O. F. Cooke (536). As *Helotium albellum* (With.) Karst. (CUP-D 8394). *Michigan:* Wheeler's woods, Ann Arbor. Oct. 29, 1931. B. B. Kanouse. (FH); *Oregon:* On quince bark? Hood River. Nov. 11, 1931. J. R. Kienholz. K12. (FH, NY); *Ontario:* Britannia. 11-9-03. As *Helotium episphaericum* Pk.? (FH-E 44, 189-13).

Two packets at Albany, apparently different collections and represented in the Durand Herbarium as Nos. 5613 and 5614, all labelled *Peziza albumina* C. & P. followed by a question mark, are referable to *Helotium herbarum* (Pers. ex Fries) Fries. It very evidently was on one or both of these specimens that Peck based his second report, on "decaying wood and stems," after he previously had described the species from wood only. The Michigan specimen cited above, kindly furnished the writer by Dr. Kanouse, was reported by her (Papers Michigan Acad. 23 (1937): 152.



FIG. 1, *Helotium scutula*, apothecia on dead hop vines,  $\times 2$  (CUP 24907);  
2, *Helotium fastidiosum*, apothecia on old leaves and petioles of *Alnus incana*,

1938) as *Helotium limonium* Cooke & Peck, which is a similar and evidently closely allied species occurring on dead herbaceous stems. The distinctive characters of *H. albuminum* are the pale color, finely puberulent exterior, small allantoid spores, and occurrence on wood or bark of trees.

- HELOTIUM SCUTULA* (Persoon ex Fries) Karsten, Symb. Myc. Fenn. Not. pro Fauna et Fl. Fenn. 11: 233. 1871; Myc. Fenn. Pars prima—Discomycetes. Bidr. Finl. Nat. Folk 19: 110. 1871; Symb. Myc. Fenn. II. Not. pro Fauna et Fl. Fenn. 13: 233. 1874; Patouillard, Tab. Anal. 38. fig. 93 a-c. 1883; Saccardo, Fungi Ital. fig. 1340. 1883; Rehm, in Rabh. Krypt.-Fl. 1<sup>a</sup>: 771. fig. 1-5. 792. 1893; 1267. 1896; Masec, Brit. Fung. Fl. 4: 253. 1895; Masec & Cr. Fung. Fl. Yorkshire 284. 1905; Boudier, Hist. Classif. 114. 1907; Migula, in Thomé Krypt.-Fl. 3: 1199. pl. 178, fig. 9-12. 1913; Grove, Trans. Brit. Myc. Soc. 15: 177. illus. 1930-31; Velenovský, Monogr. Discom. Boh. 1: 193, 2: pl. 20, fig. 24, 25. 1934.
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- Helotium vitellinum* Rehm, Ascom. Exsicc. fasc. XI, 513. Ber. Nat. Ver. Augsburg 26: 124. 1881; Boud. Hist. Classif. 113. 1907.

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× 2 (CUP 24817); 3, *Helotium naviculasporum*, apothecia on decaying leaf of *Prunus* (?), × 1 (CUP 25515); 4, *Helotium fraternum*, apothecia on decaying petioles of *Acer spicatum*, × 2 (CUP 24820).



*Helotium virgultorum* var. *scutula* (Pers. ex Fr.) Rehm, Ascom. Lojk. (Budapest) 7. 1882.

*Calycella scutula* (Pers. ex Fries) Quel. Enchr. Fung. 305. 1885.

*Helotium scutula* forma *Rubi* Rehm, Hedwigia 24: 229. 1885; Rehm, in Rabh. Krypt.-Fl. 1<sup>a</sup>: 794. 1893; Migula, in Thomé, Krypt.-Fl. 3: 1200. 1913.

*Hymenoscypha scutula* (Pers. ex Fries) Phill. Brit. Discom. 136. 1887.

*Hymenoscypha scutula* var. *Lysmachiae* Phill. Brit. Discom. 138. 1887. (Nom. nud.).

*Hymenoscypha scutula* var. *Rudbeckiae* Phill. Brit. Discom. 138. 1887.

*Phialea vitellina* (Rehm) Sacc. Syll. Fung. 8: 262. 1889.

*Phialea gracilis* (Cooke & Peck) Sacc. Syll. Fung. 8: 265. 1889.

*Phialea scutula* var. *Rudbeckiae* (Phill.) Sacc. Syll. Fung. 8: 266. 1889.

*Helotium Verbenae* Cavara, Rev. Myc. 11: 178. pl. 1, fig. 2 a-d. 1889.

*Phialea appendiculata* Oud. Versl. Med. K. Ak. v. Wet. 3: VII: 313. pl. 2, fig. 6-8. 1890; Verh. Kon. Ak. Wet. Amst. 3: XI: 345. illus. 1904.

*Belonioscypha ciliatospora* (Fuckel) Rehm, in Rabh. Krypt.-Fl. 1<sup>a</sup>: 744. 1893; see also p. 1267. 1896; Höhnelt, Österr. Bot. Zeitschr. 54: 15 (reprint?) 1904; Migula, in Thomé, Krypt.-Fl. 3: 1190. pl. 177, fig. 10-13. 1913; Zeller, Mycologia 27: 452. 1935.

*Helotium scutula* forma *vitellina* (Rehm) Rehm, in Rabh. Krypt.-Fl. 1<sup>a</sup>: 794. 1893; Peck, Rep. N. Y. State Bot. 56: 31. 1902; Migula, in Thomé, Krypt.-Fl. 3: 1200. 1913.

*Helotium scutula* forma *Lysmachiae* (Phill.) Massee, Brit. Fung. Fl. 4: 254. 1895.

*Helotium scutula* forma *Rudbeckiae* (Phill.) Massee, Brit. Fung. Fl. 4: 254. 1895; Boud. Hist. Classif. 114. 1907.

*Hymenoscyphus gracilis* (Peck) Kuntze, Rev. Gen. Pl. 3: 485. 1898.

*Helotium vitellinum* var. *pallido-striatum* Fairman, New Fungi from Western New York 231. 1904.

*Phialea vitellina* var. *pallido-striata* (Fairm.) Sacc. & Sacc. Syll. Fung. 18: 56. 1906.

*Helotium appendiculatum* (Oud.) Boud. Hist. Classif. 114. 1907.

*Helotium ciliatospora* (Fuckel) Boud. Hist. Classif. 114. 1907; Wakefield, Trans. Brit. Myc. Soc. 6: 132. 1919; Barnes, Brit. Myc. Soc. Trans. 18: 76. *illus.* 1933.

*Belospora ciliatospora* (Fuckel) Clements, Gen. Fungi 175. 1909; Atkinson, Bot. Gaz. 49: 151. 1910; Sacc. Syll. Fung. 24<sup>2</sup>: 1182. 1928. [Type of *Belospora* Clem.].

FIG. 1, 6 a-c

"Ochraceous; cups plane, then convex, immarginate, rather thin, externally slightly paler; stem slender, equal, brownish toward the base, about as long as the diameter of the cup; asci cylindrical; spores cylindric or subfusiform, obtuse at the extremities, two to three nucleate, .0007-.0008 in. long.

"Stems of herbs. Center. October.

"In size and habit it resembles *P. cyathoides*, but the cups are never closed."

The above is a copy of Peck's description. Both Peck and Ellis made several collections which they referred to this species, though both recognized it as synonymous with *Helotium scutula* as is indicated by notes on their packets. The rather lengthy synonymy includes only names which seem beyond all doubt to belong there, several others are suspected but are withheld for the present for further study, and several varieties of the species are definitely distinct, some of them deserving of specific rank.

This is our common, yellow, stipitate species of *Helotium* found in mid- and late summer on all kinds of dead herbaceous stems; it is perhaps the commonest member of the genus in both North America and Europe. Abundant material has been available from both hemispheres. The spores measure  $18-24 \times 4-5 \mu$ , are obtuse above, slightly curved and pointed toward the lower end, and about half the collections examined from both North America and Europe have a few or practically all of the spores with a small inconspicuous cilium at the lower end and much less frequently at the upper end also. No cilia could be found on the spores of Peck's type of

*H. gracile*. Most of the published illustrations of the species, nearly all of which are cited above are poor and even inaccurate, many especially tending to exaggerate the prominence of the cilium. The reader interested in additional information will find the story fairly complete under the citations of synonymy.

**HELOTIUM LIMONIUM** Cooke & Peck, in Peck, Ann. Rep. N. Y. State Mus. 26 (1872): 83. (April) 1874; Cooke, Bull. Buffalo Soc. 2: 299. 1875; Sacc. Syll. Fung. 8: 250. 1889.

*Calycina limonium* (Cooke & Peck) Kuntze, Rev. Gen. Pl. 3<sup>2</sup>: 448. 1889.

#### FIG. 7

**Apothecia** minute, more or less gregarious, solitary or in crowded groups of 3-4, slender stipitate, in the dried condition 0.3-0.6 mm. high and 0.4-0.7 mm. across the disc; **stipe** papillate, or more often definite and distinct, slender, cylindric or slightly enlarged above, smooth, pale buff; **disc** rather thin, spreading; **receptacle** in dried specimens smooth, not wrinkled, pale buff or creamy-yellow, concolorous with stipe; **hymenium** waxy, approximately plane in dried material and varying from deep bright yellow to orange; **margin** regular, smooth, sometimes slightly raised above the hymenium in dried specimens to form a slight sterile brim; **paraphyses** simple, slightly clavately enlarged at the apex, about 2-3  $\mu$  diam.; **asci** clavate-cylindric, 45-60  $\times$  5  $\mu$ ; **ascospores** biserialate cylindric or rarely slightly oblong, straight or slightly flexuous, obtuse or subobtuse at the ends, 6.5-8  $\times$  2  $\mu$ , 1-celled, the content not granular but sometimes with a group of two or three minute oil drops in one or both ends.

On dead herbaceous stems, mostly of undetermined species; one specimen said by the collector to be on *Mentha* sp. (Iowa).

Previously reported from New York and erroneously from Michigan; material has been examined from Iowa and New York. Sept.-Oct.

**MATERIAL EXAMINED:** *New York:* Center. Oct. C. H. Peck (294). (NYS; CUP-D 3447, 5964, 5965, 8462); *Iowa:* Iowa City. Oct. 10, 1936. \* G. W. Martin, 5194. (FH); *Locality unknown:* Ex Herb. Ellis, as *Helotium album* Schum. (No other data supplied). (FH).

At Albany there is a packet containing a large amount of material and bearing the following data: "294. *Helotium limonium* C. & P. Center. Oct." In addition there is a sheet on which are pasted four pieces of stem and bearing no data other than the locality. A drawing by Peck accompanying the sheet shows allantoid spores, but examination of an apothecium from one of the pieces (lower right) shows them to be straight and in perfect agreement with those of all the other numbers cited above. No. 3447 in the Durand Herbarium bears Peck's number 294 and is marked "type." The range of numbers on the Durand packets is evidence of duplication as a result of two or three different visits to the Peck Herbarium. It seems highly probable that Peck made only one collection of the species.

Distinguished from *H. albuminum* by its very slender, brightly colored apothecia with smooth receptacle and stipe, straight spores, and occurrence on dead herbaceous stems. The specimen reported by Miss Kanouse (Papers Michigan Acad. 23 (1937): 152. 1938) as *Helotium limonium* is here referred to *H. albuminum*.

***Helotium destructor* Peck, nom. nov.**

*Peziza subcarnea* Cooke & Peck, in Cooke, Synop. Discom. U. S., Bull. Buffalo Soc. Nat. Sci. 295. Mr 1875; Peck, Ann. Rep. N. Y. State Mus. 27 (1873): 107. (Dec.) 1875. [Not *Peziza subcarnea* Schum. = *Helotium subcarneum* (Schum.) Sacc. *Michelia* 2: 260. 1881.]

*Phialea subcarnea* (Cooke & Peck) Sacc. Syll. Fung. 8: 265. 1889; Povah, Papers Michigan Acad. 20 (1934): 129. *pl.* 23, fig. 2. 1925.

*Hymenoscyphus subcarneus* (Cooke & Peck) Kuntze, Rev. Gen. Pl. 3<sup>2</sup>: 486. 1889.

FIG. 8

**Apothecia** minute, scarcely visible to the unaided eye, solitary, sparse or rather numerous, originating from the leafy branches, stipitate, in the dry condition pale yellow or hyaline-yellow, concolorous throughout, waxy-cartilaginous, reaching a height of 1 mm. and a diameter across the disc of 0.5 mm. though usually considerably smaller; when young papillate, then elongating, enlarging at the apex, becoming subglobose with a rather deep pore;

**stipe** long for the size of the apothecium, rather firm, about 0.3–0.5 mm. long, cylindric, slightly broadened at juncture with disc, not wrinkled in drying, hyaline-yellow in dried material, entirely smooth or more rarely with a thin scattering of white cottony hyphae about the base; **disc** at first subglobose, then shallow-infundibuliform, finally saucer-shaped, with turned up margin, rather thick, about 0.2–0.4 mm. diam.; **receptacle** entirely smooth, of color and consistency comparable to that of the stipe, not wrinkled in drying; **hymenium** waxy to waxy-cartilaginous, in dried material similar in color and consistency to other parts or sometimes of a more opaque cream-yellow; **margin** circular, smooth, elevated, obtuse; **paraphyses** simple or once or twice forked, scarcely or not at all enlarged at apex, 3–3.5  $\mu$  diam.; **asci** 40–50  $\times$  5–6  $\mu$ ; **ascospores** piriform, 4.5–6  $\times$  2–2.5  $\mu$ , the content not granular, biseriate.

Growing on and apparently killing various species of Jungermaniaceous liverworts and mosses; *Jungermania* sp. (Peck, type). *Dicranum flagellare* Hedw. (Povah, l. c. and spec. coll. H. S. Jackson, 1548).

Previously recorded from New York, Michigan, and Alberta; material has been examined from these regions and also from New Hampshire and Ontario. Peck's type was dated July; otherwise all known collections were made in September. Probably not uncommon in eastern U. S. and Canada.

**MATERIAL EXAMINED:** *New York:* Indian Lake. July. Peck, 319. Type. (CUP-D 3751, NY, NYS); Indian Lake. July. Peck. (Dupl.). (CUP-D 5855); Adirondack Mts. Aug. Peck. (CUP-D 5853, NY); Catskill Mts. Peck. (NYS, CUP-D 5854); Cattin Lake. Peck. (CUP-D 9109); Essex Co. Aug., 1888. *G. A. Rex.* (CUP-D 8368, NY); Adirondack Mts. *Rex.* E. & E. N. Am. Fungi 2143. (CUP-D 2981, FH); *New Hampshire:* All collected by Farlow at Shelburne: Sept., 1891. (CUP-D 8403); Sept., 1891. (Dupl.). CUP-D 10288; Sept., '93. (FH); Sept., 1897 (CUP-D 10287, FH); Sept., 1897. (FH); *Michigan:* E. T. Harper, 3297. (CUP-D 3265); Sept. 1, 1930. J. L. Lowe. Ex Herb. Univ. Mich. (FH); *Ontario:* Bear Island, L. Temagami, Sept. 15, 1929. H. S. Jackson (1548) & G. Thompson (NY); Round Lake, Temagami Forest Reserve. Sept. 2, 1932. Jackson. Univ. Toronto, 5854 (FH); Diamond Lake, T.

F. R. Sept. 2, 1935. *Jackson*. Toronto, 7999. (FH); Long Pt., L. Temagami, T. F. R. Sept. 10, 1936. *R. F. Cain*. Toronto, 10094. (OTB); *Alberta*: Lac Clair. Sept. 1888. (FH).

The pathogenic habit of the species was noted by Peck in his original description and has also been observed by Dr. Jackson who informs the writer that the apothecia are best located by first searching out the brown areas in green patches of mosses where the plants have evidently been killed by the fungus. There seem to be no morphological differences between the forms on liverworts and those on mosses. A large number of inoperculates have been described on liverworts and especially on mosses, but in so far as can be determined *H. destructor* is distinct.

HELOTIUM FASTIDIOSUM Peck, Ann. Rep. N. Y. State Mus. 27 (1873): 107. (Dec.) 1875; Sacc. Syll. Fung. 8: 221. 1889. *Calycina fastidiosa* Kuntze, Rev. Gen. Pl. 3<sup>2</sup>: 448. 1898.

#### FIGS. 2, 9

**Apothecia** small, slender, delicate, stipitate, 1–1.5 to rarely 3 mm. high, 0.8–1.5 mm. diam. across the disc; **stipe** very slender, sub-cylindric, smooth, dilute white to practically hyaline, sometimes more or less discolored toward the base, thickened slightly just below the disc, expanding abruptly into disc, not changing in drying except for a deepening of the color to a hyaline-yellow or pale whitish-yellow, sometimes becoming light brown especially on the lower portion; **disc** flat expanded at maturity, medium thin; **receptacle** smooth, dilute white to whitish-yellow, rarely varying to pale ochraceous with age, not changing on drying except for a slight deepening of color; **hymenium** slightly convex with maximum water content, opaque, white or more often pale yellow, on drying becoming plane to saucer-shaped, waxy, the color deepening somewhat to pale or bright yellow, approximating apricot yellow (R), or more rarely as dark as deep chrome; **paraphyses** simple, slightly or not at all enlarged at apex, 2.5–3.5  $\mu$  diam.; **asci** not originating from croziers, clavate, 80–100  $\times$  9–12  $\mu$ ; **ascospores** clavate, slightly curved, the curvature mostly near the upper end, 26–36  $\times$  3.5–4.5  $\mu$ , biseriate, each containing a single row of from 6–10 oil globules.

On petioles and midveins of decaying leaves of *Alnus incana*, *Alnus* sp., and decaying catkin of undet. species, probably *Alnus*.

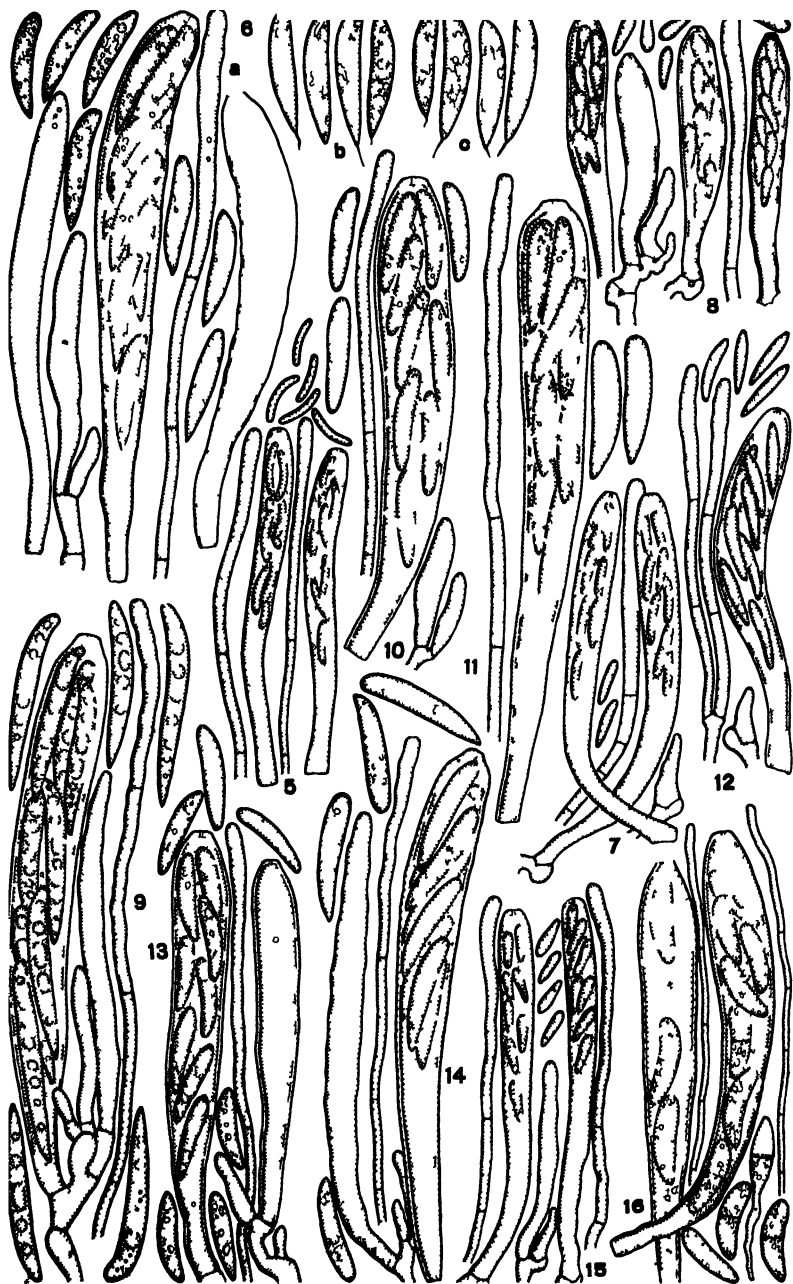


FIG 5, *Helotium albuminum*,  $\times 915$  (CUP-D 5612), 6, *Helotium scutula* a, type of *Helotium gracile* Cooke & Peck,  $\times 850$  (NYS), b, Herb Barbey-

Previously known only from Peck's New York material; material has been examined from New York, Oregon, and Quebec. August and September. Common in New York and probably also elsewhere.

MATERIAL EXAMINED: *New York*: Forestburg. Sept. Peck. Type. (NYS, CUP-D 5948); Adirondack Mts. Peck. (NYS, CUP-D 5949); Labrador Lake, near Tully. Aug. 26, 1935. Whetzel & White. (CUP 24817, FH); Lloyd Preserve, McLean. Sept. 6, 1935. Whetzel, White (2040), & D. P. Rogers. (FH). *Oregon*: Tilly Jane Creek, Mt. Hood. Aug. 26, 1933. J. Kienholz. 137. Comm. Miss Cash ex U. S. D. A. Path. & Mycol. Coll. (FH). *Quebec*: Duchesnay. Aug. 24, 1938. Whetzel. (CUP 27414, FH); Duchesnay. Aug. 26, 1938. Whetzel. White no. 3368. (FH); Duchesnay. Aug. 26, 1938. Whetzel. White no. 3372. (FH).

*Helotium fastidiosum* appears not to have been recorded again since the original description. It seems to be easily distinct from all other species known to the writer. In its long, narrow, characteristically shaped spores it is distinct from nearly all other members of the genus, and from all save one, *Helotium Dearnessii* (Ellis & Ev.) comb. nov. (Syn.: *Phialea Dearnessii* Ellis & Ev.), which have thus far been found in Eastern North America. The latter, known only from the type taken at London, Ontario, and a more recent collection by J. W. Groves from Duchesnay, has greatly elongated spores which are, however, characteristic in their acute apex and long attenuate base, and the species occurs on dead herbaceous stems. Other closely allied species are *Helotium scutula* (Pers. ex Fries) Karst. which occurs on dead herbaceous

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Boissier 1302 as *Helotium scutula*,  $\times 850$  (FH); c, Jaczewski, Komarov, & Tranzschel, Fungi Rossiae Exsiccati 243 as *Bclonioscypha ciliatospora*,  $\times 850$  (F); 7, *Helotium limonium*,  $\times 915$  (CUP-D 5964); 8, *Helotium destructor*, from specimen taken in Catskill Mts. by Peck,  $\times 850$  (NYS); 9, *Helotium fastidiosum*,  $\times 850$  (CUP 27414); 10, *Helotium turbinatum*: type of *Helotium bryogenum* Peck,  $\times 915$  (CUP-D 5924); 11, *Helotium naviculasporium*, from Sydow, Mycotheca Marchica 3772, as *Helotium sordatum* Karst.,  $\times 915$  (FH); 12, *Helotium planodiscum*, type,  $\times 850$  (NYS); 13, *Helotium albopunctum*, type,  $\times 850$  (NY); 14, *Helotium fraternum*, type,  $\times 850$  (FH); 15, *Helotium episphaericum*, type,  $\times 915$  (CUP-D 5947); 16, *Helotium mycetophilum*, type,  $\times 915$  (CUP-D 5973).



stems, and *H. naviculasporum* Ellis on decaying leaves; both have spores somewhat shorter and broader than are those of *H. fastidiosum*.

**HELOTIUM TURBINATUM** (Fuckel) Boudier, Hist. Classif. Discom. Europe 113. 1907.

*Leucoloma turbinata* Fuckel, Symb. Myc. 318. 1869.

*Helotium bryogenum* Peck, Ann. Rep. N. Y. State Mus. 30 (1876): 61. (Nov.) 1878; Sacc. Syll. Fung. 8: 213. 1889.

*Humaria turbinata* (Fuckel) Sacc. Syll. Fung. 8: 127. 1889.

*Plicaria turbinata* (Fuckel) Rehm, in Rabh. Krypt.-Fl. 1<sup>8</sup>: 1009. 1895.

*Belonium bryogenum* (Peck) Rehm, Ascom. 1279; Hedwigia 38: 244. 1898.

*Calycina bryogena* (Peck) Kuntze, Rev. Gen. Pl. 3<sup>2</sup>: 448. 1898.

*Helotium turbinatum* (Fuckel) Boud. Hist. Classif. 113. 1907.

*Calycella turbinata* (Fuckel) Höhnelt, Sitz.-ber. Akad. Wien. 127<sup>1</sup>: 594 (46). 1918.

#### FIG. 10

**Apothecia** solitary, sparse, short-stipitate, fleshy, medium brown when dry, reaching a height of 0.3 mm. and a diameter of about 0.8 mm.; **stipe** short but usually distinct, stout, cylindric, smooth, when dry medium brown and not at all wrinkled; **disc** thick, fleshy, 0.3–0.8 mm. diam. in dried specimens, the larger reaching 1 mm. when moistened; **receptacle** concolorous with stipe, smooth, not wrinkling in drying; **hymenium** in dried specimens medium to dark brown, waxy to waxy-cartilaginous, plane to slightly concave; **margin** obtuse, smooth, even, not elevated above hymenium; **paraphyses** simple or once branched near the base, slightly clavately enlarged at the apex; **asci** clavate,  $70\text{--}90 \times 8\text{--}11 \mu$ , sometimes noticeably broad at the base, not originating from croziers; **ascospores** elongate, straight or very slightly curved, 1- or rarely 2-celled,  $16\text{--}23 \times 3\text{--}4 \mu$ , slightly oblong, the ends obtuse or more or less pointed, biseriolate.

On various mosses; previously recorded in the literature on *Polytrichum juniperinum* (Europe), *Hypnum* sp. (Europe), and *Hypnum delicatulum* (N. Am.).

Known only from New York and Germany. The single New York collection was made in September.

MATERIAL EXAMINED: **North America:** *New York:* Maryland, Otsego Co. Peck. Type of *Helotium bryogenum*. (CUP-D 5924, FH). **Europe:** *Germany:* Near Heidelberg. Fuckel, Fungi Rhen. 1177. Incorrectly labeled *Peziza muscorum* Fr. (FH); "Dahren bei Bautzen (Sachsen)." Feurich. Rehm, Ascom. 1279. (FH); "Bei Dahren nächst Göda." Dec. 11, 1910. Krieg. Fungi Saxon. 2168. (FH). On *Polystichum commune*. "Hohe Kammer bei Matten (Rhön)." Nov. 15, 1916. (FH-H); On *Cryptodon Hartmannii*. "Steinernes Moor bei Oberriedenberg (Rhön)." Nov., 1916. Ade. (FH-H); On *Hymen cupressiforme*. "Dahren in Sachsen." June 30, 1918. Feurich. (FH-H).

This species seems not to have been recorded again for America since Peck's original description. Several good descriptions have appeared under the various names in European literature. The brief summary by von Höhnelt (l. c.), while based largely on assumption, nevertheless seems to be correct.

Several collections in the Durand Herbarium as *Helotium bryogenum*, represent, exclusive of a fragment of Peck's type, the lichen, *Microphiala diluta*. There scarcely are any characters, either superficial or microscopic, to account for such mistaken identification.

*HELOTIUM NAVICULASPORUM* Ellis, Bull. Torrey Club 5: 46. 1874; Cooke, Bull. Buffalo Soc. Nat. Hist. 2: 299. 1875; Sacc. Syll. Fung. 8: 211. 1889; Ellis, Cat. Pl. New Jersey 551. 1890; Rehm, in Rabh. Krypt.-Fl. 1<sup>3</sup>: 780. 1893.

*Helotium saprophyllum* Cooke & Peck, in Peck, Ann. Rep. N. Y. State Mus. 29 (1875): 55. 1878; Cooke, Bull. Buffalo Soc. 3<sup>1</sup>: 23. 1875. As *nom. nud.*; Sacc. Syll. Fung. 8: 227. 1889. *Calycina naviculaspora* (Ellis) Kuntze, Rev. Gen. Pl. 3<sup>2</sup>: 448. 1898.

*Calycina saprophylla* (Cooke & Peck) Kuntze, Rev. Gen. Pl. 3<sup>2</sup>: 449. 1898.

*Helotium sparsum* Boud. Hist. Classif. Discom. Europe 111. 1907; Icones Myc. pl. 495. 1905-10; Sacc. Syll. Fung. 22<sup>1</sup>: 649. 1913; Kanouse, Papers Michigan Acad. 22 (1936): 119. 1937.

## FIGS. 3, 11

**Apothecia** scattered, sparse, minute, delicate, slender-stipitate, hyaline-white when fresh, becoming opaque and more or less yellowish or ochraceous on drying, reaching a height of 0.75–1.5 mm. and a diameter across the disc of 0.4–1.3 mm.; **stipe** slender, delicate, smooth, dilute white when fresh, sometimes yellowish at the substratum, drying semi-opaque and white to creamy yellow; **disc** at first elongate, thick, wine-glass shaped, plane, then expanding and at maturity spreading, of medium thickness, immarginate; **receptacle** smooth, hyaline to dilute white when fresh, drying opaque and yellowish; **hymenium** plane from the very young stages to complete maturity, finally somewhat convex with maximum moisture content, tender, white, more opaque than stipe and receptacle, drying waxy and pale yellow to ochraceous, remaining plane or nearly so; **paraphyses** simple, slightly or not at all enlarged at apex,  $2\text{--}3\ \mu$  diam.; **asci** clavate,  $80\text{--}90\text{--}(110) \times 8\text{--}11\ \mu$ ; **ascospores** elongate, slightly curved, obtuse above, pointed at lower end,  $16\text{--}21 \times 4\text{--}5\ \mu$ , typically more or less filled with irregular refractive granules, biseriate.

On fallen decaying leaves, the apothecia usually originating from the midrib or veins, more rarely on petioles or parenchyma of blade: *Acer* sp., *Alnus incana*, *Carya* sp., *Fagus grandifolia*, *Tilia americana* in North America, and on *Alnus* sp., *Quercus* sp., and *Spiraea* sp. in Europe.

Previously recorded for New York, New Jersey, Michigan, and France; material has been examined from all of these regions and in addition from Germany. A late summer species common in New York from July through September.

**MATERIAL EXAMINED: North America: New York:** Lake Pleasant. Peck. Type of *Helotium saprophyllum*. (NYS, CUP-D 5987); Indian Lake. August. Peck. (CUP-D 5989, NYS); Adirondack Mts. Peck. (CUP-D 5990, NYS); Lowville. Sept. Peck. (NYS); Sandlake. July. Peck. (CUP-D 5832); Ridgeway, Orleans Co. 1904. C. E. Fairman, 33. (CUP-D 462, NYS); Labrador Lake, near Tully. Aug. 26, 1935. Whetzel & White. (CUP 24821, FH); Lloyd Preserve, McLean. Oct. 20, 1935. Whetzel & White. (FH); Old Forge, Adirondack Mts. Sept. 3, 1936. Whetzel & White. (CUP 25515, FH); Little Ravine, below Newfield, near Ithaca. Sept. 14, 1938. Whetzel,

*White, & Sproston*. (CUP 27890, FH, U. S. D. A.); same locality and date. (CUP 27891, FH). *New Jersey*: All Ellis collections as *Helotium naviculasporum*: Ellis, *Fungi Nova-Caesareenses* 53 (NY); Ellis, *N. Am. Fungi* 62 (CUP-D 2972, NY); Newfield. 2 June, 1876. (CUP-D 8465); Newfield. July, 1876. (FH). *Michigan*: Marquette. Sept. 10, 1934. *E. B. Mains*, 34-144. Comm. Miss Kanouse as *Helotium sparsum*. (FH). **Europe**: *France*: Env. le Rouen. 8-1889. Leg. Letendre, 2087. Incorrectly determined as *Helotium scutula* var. *albida*. (FH-P). *Germany*: Berlin. 10, 1892. Sydow, *Myc. March.* 3772. Incorrectly determined as *Helotium sordidatum* Karst. (FH).

All the specimens cited agree remarkably well in their characters with the exception of the Michigan collection and CUP 27890 from New York, which vary slightly in spore shape from the typical form.

***Helotium planodiscum*** (Peck & Cooke) comb. nov.

*Peziza* (*Mollisia*) *planodisca* Peck & Cooke, in Peck, *Ann. Rep. N. Y. State Mus.* 31 (1877): 46. (March) 1879.

*Pezizella planodisca* Sacc. *Syll. Fung.* 8: 281. 1889.

*Hymenoscypha planodisca* Lindau, in Engler & Prantl, *Nat. Pfl.* 1<sup>1</sup>: 204. 1897.

FIG. 12

**Apothecia** scattered or subgregarious, pale yellow, sessile, attached by a narrow or less frequently rather broad basal portion but always free toward the margin, reaching a diameter of 0.4 mm. though typically smaller, rather thick; **receptacle** in dried material cream colored to pale yellow, smooth; **hymenium** entirely plane from the earliest stages and always remaining so, pale yellow and waxy in the dried condition; **margin** smooth, subobtuse, regular, not at all elevated; **paraphyses** simple or once or twice branched usually near the base, colorless, clavately enlarged, obtuse, 2.5-3.5  $\mu$  diam.; **asci** originating from croziers, clavate, slightly narrowed to a thick pedicel, 40-55  $\times$  5-7  $\mu$ ; **ascospores** elongate, straight or slightly curved, narrow oblong fusiform, lacking oil globules, 8-13  $\times$  2-2.5  $\mu$ , obliquely uniseriate with ends strongly overlapping, or biseriate.

On dead leaves and culms of *Andropogon scoparius*. Known only from the type collection.

MATERIAL EXAMINED: *New York*: Buffalo. G. W. Clinton. Type. (NYS).

This species appears to be very closely allied with *Helotium flexuosum* Massee (Syn.: *H. citrinulum* Karst. var. *Seaveri* Rehm), which the writer has collected and observed frequently in the vicinity of Ithaca, N. Y., growing on the moist basal parts of leaves and culms of sedges and grasses in May and June. It may later prove synonymous, but since the type, which is very ample and in good condition, differs in certain characters from all the collections that have been referred to *H. flexuosum*, it is desirable that they be kept separate for the present. The latter has apothecia which are rather thin and spreading, frequently reaching a diameter of 1.8 mm., are more or less brightly colored, and field observations over a period of years indicate that they are never to be found after late June. Peck records the collection date for his type as "Nov." but there is good reason to believe that this represents something other than the date of collection—perhaps the date of receiving the material from Clinton. Other instances of such confusion have been encountered.

HELOTIUM ALBOPUNCTUM Peck, Ann. Rep. N. Y. State Mus. 31 (1877): 47. (March) 1879. [Not *Helotium albopunctum* (Desm.) Bucknall, Bristol Nat. Soc. Proc. 3: 137. 1882.]  
*Pezizella albopuncta* Sacc. Syll. Fung. 8: 276. 1889.  
*Hymenoscyphus albopunctus* Kuntze, Rev. Gen. Pl. 3<sup>2</sup>: 485. 1898.

FIG. 13

**Apothecia** scattered, solitary, punctiform, when dry visible to the unaided eye only as dots, waxy-cartilaginous, the color to the naked eye similar to that of the dried beech leaves on which they occur, under magnification pale yellow to pale orange, *Pezicula*-shaped, narrowed to a central point of attachment or sometimes to a very short but definite stipe; **disc** rather thick; **hymenium** plane to slightly concave; **margin** elevated to form a slight sterile region about the hymenium; **paraphyses** simple, slightly clavate-enlarged above, 2.5–3.5  $\mu$  diam.; **asci** 60–70  $\times$  8–10  $\mu$ , not originating from croziers; **ascospores** elongate, straight or slightly curved, rounded above, obtuse-pointed at lower end, 14–16  $\times$  3.5–4  $\mu$ , biseriate, 1-celled, containing a few granules in the cytoplasm.

On *Fagus grandifolia*, fallen leaves of the previous season, little or not at all decayed. Known only from the type. August.

MATERIAL EXAMINED: *New York*: Adirondack Mts. *Peck*. *Type*. (CUP-D, NY, NYS).

The type packet at Albany contains seven leaves, each with a fairly large number of apothecia. While the ampleness of this collection might lead one to suspect that the species is not of rare occurrence, nevertheless it has not again come to light in the considerable collecting of the writer in New York. Cummins (Papers Michigan Acad. 11 (1929): 111. 1930) reports the species on the "leaves of Cornus?" from Montana. His material has not been seen but there is no reason from his description to doubt his determination.

*HELOTIUM FRATERNUM* Peck, Ann. Rep. N. Y. State Mus. 32 (1878): 47. (May) 1880: Bull. N. Y. State Mus. 1<sup>2</sup>: 21. *pl. 1, fig. 12-15*. 1888; Sacc. Syll. Fung. 8: 218. 1889; Kauffman, Rep. Michigan Acad. 12: 101. 1910; Coons, Rep. Michigan Acad. 14: 260. 1912; Millspaugh, West Virginia Geol. Survey 5 (A): 111. 1913. *Calycina fraterna* Kuntze, Rev. Gen. Pl. 3<sup>2</sup>: 448. 1898.

FIGS. 4, 14

**Apothecia** scattered, solitary, stipitate, 1-2.5, rarely 3.5 mm. high, up to 2.2 mm. diam.; at first appearing as erumpent papillae, elongating, becoming cylindric, columnar, a minute pore appearing at the apex followed by expansion of the disc which is subglobose, then shallow cupulate, finally fully expanded, rather fleshy when fresh, of medium thickness; **stipe** and **receptacle** smooth, more or less concolorous, pale yellow to whitish when fresh, sometimes varying to reddish brown toward the substratum, on drying retaining the original shape, rarely becoming very slightly wrinkled, typically becoming orange-buff with a silky or resinous lustre, more rarely dilute-yellow or grayish; **hymenium** at maturity and with maximum moisture content convex, immarginate, concolorous with stipe and receptacle when fresh, wax-yellow to ochraceous orange (R), on losing moisture becoming slightly concave with rather thin elevated margin, the color changing to a deep reddish brown; **paraphyses** simple, scarcely or not at all enlarged at the apex, 2-3  $\mu$  diam., colorless in fresh material, the content usually brown-

ish in old specimens; **asci** clavate-cylindric,  $70-100 \times 10-12 \mu$ ; **ascospores** biseriate or subbiseriate, narrow oblong-fusoid, usually very slightly curved, typically with an oil drop in each end but these sometimes confluent or broken into several smaller globules.

On decaying petioles of *Acer*; noted on *A. saccharinum*, *A. saccharum*, *A. spicatum*, and *Acer* sp.

Previously reported from New York, West Virginia, and Michigan. Material has been examined from the states listed below.

**MATERIAL EXAMINED:** *New York:* Adirondack Mts. July. *Peck. Type.* (CUP-D, FH, NY, NYS); North Elba. July. *Peck.* (NYS); Tichner's Glen, Canandaigua. Aug., 1894. *Durand.* (CUP-D 600); Mt. Whitney, L. Placid. Sept. 3, 1894. *G. F. Atkinson.* (CUP-D 9531); Fall Creek, Ithaca. Aug. 8, 1895. *Durand.* (CUP-D 831); Tichner's Glen, Canandaigua. Sept. 7, 1900. (CUP-D 955); Taughannock, Cayuga Lake Basin. Aug. 6, 1904. *Kauffman.* (CUP-D 2640); North of Hudson Falls, Wash. Co. Aug. 12, 1918. *Burnham.* (CUP 26646, FH, NY); Lloyd Preserve, McLean, Aug. 6, 1935. *Whetzel & White.* (CUP 24800, FH); Labrador Lake, near Tully. Aug. 21, 1935. *Whetzel & White.* (CUP 24820, FH); Labrador Lake. Aug. 26, 1935. (FH); Lloyd Preserve, McLean. Sept. 6, 1935. *Whetzel & White.* (FH); Labrador Lake. Aug. 12, 1936. *Whetzel & White.* (CUP 25455, FH); another collection. (FH); Lloyd Preserve, McLean. Aug. 18, 1936. *Whetzel & White.* (CUP 25486, FH); another collection. (CUP 25487, FH); Cascadilla Gorge, Ithaca. Aug. 29, 1936. *White.* (FH); Adirondack Mts. Sept. 3, 1936. *Whetzel, White, & Viegas.* (FH); Old Forge, Adirondack Mts. Sept. 3, 1936. *Whetzel & White.* (FH); Little Ravine below Newfield, near Ithaca. Sept. 14, 1938. *Whetzel & White.* (FH). *Maine:* Millinocket. Sept. 22, 1940. *Linder & White.* (FH). *New Hampshire:* Chocorua. 1907. *Farlow.* (FH, NYS). *Ohio:* Oxford. Aug. 11, 1908. *Bruce Fink, Fink, Ascom.* Ohio 51. (CUP-D 10715). *Indiana:* Turkey Run, Montgomery Co. Aug. 23, 1917. *Fink, Ascom.* Indiana 138. (CUP-D 10714). *West Virginia:* Albright. Aug. 4, 1908. *J. L. Sheldon.* (CUP-D 6504).

Field observations on this species indicate that, as is also true of many other species of Discomycetes, the color and consistency of the fruit body depend largely upon growing conditions. If apothecial production is retarded or prevented for any considerable period during the time of normal fruiting, and if this period is then followed by a two or three day period of rain, the apothecia develop very rapidly; they are then likely to be of a pale hyaline-yellow color and to be practically concolorous throughout, and in drying they shrivel somewhat and retain the dilute-yellow cartilaginous appearance. If on the other hand the infested petioles are subjected to a normal, more or less continuous supply of moisture and a certain amount of sunlight, then the apothecia develop more slowly and are marked by a greater depth of color, are more opaque and waxy, and in drying retain both the color and fullness of form of the fresh material. Developed under such conditions the apothecia of this species exhibit in the field, as well as in the herbarium, a most perfect and symmetrical form.

Thus far no other species of *Helotium* has come to the attention of the writer as occurring on the petioles of *Acer*, although certain species known to grow on a wide range of frondose tree dejecta are to be expected here also. A species of *Rutstroemia*, *R. luteovirescens* (Rob.) White (Lloydia 4: 211. 1941) occurs on maple petioles within the range of *H. fraternum* but is comparatively uncommon. The apothecia of the two species are of similar size, form, and color, but in the *Rutstroemia* they are fairly well marked superficially by the presence of an olive-green cast and by their origin from a stroma, and microscopically by larger asci and larger, ellipsoid spores.

Peck's type contains abundant material and it is in excellent condition.

- HELOTIUM EPISPHERICUM* Peck, Ann. Rep. N. Y. State Mus. 40 (1886): 66. (Jan.) 1888; Sacc. Syll. Fung. 10: 8. 1892.  
*Calycina episphaerica* Kuntze, Rev. Gen. Pl. 3<sup>2</sup>: 448. 1898.  
*Helotium parasiticum* Ellis & Ev. Jour. Myc. 9: 165. 1903; Sacc. Syll. Fung. 18: 54. 1906.  
*Dermatea mycophaga* Massee, Kew Bull. Misc. Inf. 218. 1908; Sacc. Syll. Fung. 22<sup>1</sup>: 712. 1913.



FIG. 15

**Apothecia** minute, sessile or subsessile, 0.2–0.5 mm. in diam., gregarious, solitary or in crowded groups of two to six, in the dried condition waxy-cartilaginous, concolorous throughout, pale yellow to bright orange, usually close to orange-rufous (R); **stipe** usually consisting only of a V-shaped papilla-like attachment, more rarely tending to elongate, smooth; **receptacle** entirely smooth; **margin** slightly elevated, smooth, not at all furfuraceous or puberulent; **hymenium** saucer-shaped in the dried condition; **flesh** white when broken; **ectal excipulum** consisting of thin-walled isodiametric cells; **paraphyses** simple, very slightly enlarged at the apex, about  $2\ \mu$  diam.; **asci** clavate-cylindric,  $48\text{--}65 \times 5\ \mu$ ; **ascospores** narrow-piriform, 1-celled,  $4.5\text{--}7 \times 1.8\text{--}2.5\ \mu$ , uniseriate or subbiseriate, usually with a very small oil globule in each end.

On stromatic pyrenomycetous fungi. The substrata as recorded by the collectors is listed below for each collection cited.

Known from New York, Ontario, Germany, and Straits Settlements. Sept. in N. Y. and Ont.; Aug. in Germany.

**MATERIAL EXAMINED:** **North America:** *New York:* On *Hypoxylon Morsei*. Elizabethtown. Sept. Peck. Type of *Helotium episphaericum*. (CUP-D 5947, NYS). *Ontario:* On *Valsa?* Harraby, Lake Rosseau. Sept., 1902. E. T. & S. A. Harper. Type of *Helotium parasiticum*. (FH). On *Diatrypella*. London. Oct., '03. J. Dearnness. (FH-E 2998; 189–13). **Europe:** *Germany:* Ybbsitz. August. Leg. Strasser. (FH-H); **Asia:** *Straits Settlements:* On *Xylaria*. Selangor. Ridley, 158. Type of *Dermatea mycophaga* Massee. (NY). Only Massey's notes and colored drawings are there; specimen missing!

The species is very closely allied to two others, *H. hymeniophilum* (Karst.) Karst. on the pore surface on various species of *Polyporaceae* in Finland, and *H. griseolum* von Höhnelt on the pore surface of *Polyporus conrescens* Mont. from Java. The former (Karst. Fungi Fenniae 730 examined) differs in being a rather dull yellowish to more or less cineraceous in color and in having the excipular and marginal cells extended into definite cylindric, obtuse hairs which are rough as in *Dasyscypha*, and in its somewhat shorter asci. The latter, *H. hymeniophilum* (type in von Höhnelt Herbarium examined), has apothecia more definitely stipitate, cineraceous-buff in color, with excipular hairs as in *H. hymenio-*

*philum* but smooth. The three species should be maintained as distinct at least for the present. Another species, *Pezizella anonyma* Rehm (Rehm, Ascom. 115b, type, examined) on the stroma of *Valsaria crenata* in Ecuador is of very similar aspect to *H. episphaericum* but is smaller and has subglobose spores.

HELOTIUM MYCETOPHILUM Peck, Ann. Rep. N. Y. State Mus. 43 (1889): 33. (Oct.) 1890; Sacc. Syll. Fung. 10: 8. 1892.  
*Calycina mycetophila* Kuntze, Rev. Gen. Pl. 3<sup>a</sup>: 448. 1889.

#### FIG. 16

**Apothecia** scattered or gregarious, appearing singly or more rarely two crowded together, when dry minute, substipitate, 0.1–0.3 mm. diam., more or less turbinate, waxy, dark red and concolorous throughout; **stipe** consisting only of the tapering basal portion of the receptacle or sometimes distinct and cylindric though very short; **disc** rather thick, immarginate; **receptacle** smooth, tapering downward; **hymenium** waxy-cartilaginous, plane or slightly concave when dry; **paraphyses** simple, slightly flexuous, cylindric, scarcely more than 1 mm. diam.; **asci** clavate, 100–120  $\times$  13–15  $\mu$ ; **ascospores** uniseriate below, biseriate above, narrow ellipsoid or oblong-ellipsoid, slightly curved or at least flattened on one side, 1–2-celled, 17–21  $\times$  5.5–7  $\mu$ , filled with minute oil globules at least in dried specimens.

On pileus of old sporophore of *Fomes fomentarius*.

Known only from the type collection from New York. August.

MATERIAL EXAMINED: *New York*: Rainbow Lake. August. Peck. Type. (CUP-D 5973, NYS).

The collection left at Albany by Peck consists of rather ample material in a packet, plus four pieces of the substrate pasted openly on an herbarium sheet. The apothecia are dull red in color and in this respect as well as in form they resemble a small, slender *Pezicula*.

#### EXCLUDED SPECIES

HELOTIUM MACROSPORUM Peck, Ann. Rep. N. Y. State Mus. 26 (1872): 82. (June) 1874. = *Rutstroemia macrospora* (Peck) Kanouse *apud* Wehmeyer, Canad. Jour. Res. 18: 547. 1940. Species treated fully by White, Lloydia 4: 184. 1941.

HELOTIUM RUGIPES Peck, Ann. Rep. N. Y. State Mus. 26 (1872): 82. (June) 1874. = *Chlorociboria versiformis* (Pers. ex Fr.) Seaver, Mycologia 28: 393. 1936.

HELOTIUM THUJINUM Peck, Ann. Rep. N. Y. State Mus. 26 (1872): 82. (June) 1874. = *Pithya Cupressi* (Batsch ex Fries) Rehm. See Seaver, N. Am. Cup-Fungi 78. 1928.

HELOTIUM PILEATUM Peck, Ann. Rep. N. Y. State Mus. 28 (1874): 67. 1876. = *Ombrophila clavus* (Alb. & Schw. ex Fr.) Cooke. Later Peck (Rep. 32 (1878): 58. 1880) recorded a second collection which he considered a larger form of the species.

HELOTIUM HYDROGENUM Peck, Ann. Rep. N. Y. State Mus. 29 (1875): 56. 1878. A species of *Mollisia*.

HELOTIUM CARICINELLUM Peck, Ann. Rep. N. Y. State Mus. 30 (1876): 61. (Nov.) 1878. Probably referable to the Patellariaceae.

HELOTIUM PALUSTRE Peck, Ann. Rep. N. Y. State Mus. 32 (1879): 48. (May) 1880. = *Ombrophila clavus* (Alb. & Schw. ex Fr.) Cooke.

HELOTIUM VIBRISSOIDES Peck, Ann. Rep. N. Y. State Mus. 32 (1878): 48. (May) 1880. Later Peck (Bull. N. Y. State Mus. 12: 28. 1888) indicated that his species was synonymous with *Vibrissia turbinata* Phill. and that the name *Gorgoniceps turbinata* (Phill.) Sacc. should be adopted. The species belongs in *Apostimidium* Karst. which is in a phylogenetic series unrelated to *Gorgoniceps* Karst., but the species concept in *Apostimidium* is much too confused to attempt to settle the question of the specific name at this time.

HELOTIUM AFFINISSIMUM Peck, Ann. Rep. N. Y. State Mus. 33 (1880): 32. 1883. = *Lachnum pygmaeum* (Fries) Bres., Ann. Myc. 1: 121. 1903. A long list of synonymy is involved here. Names based on North American material are *Helotium rhizogenum* Ellis & Ev. (Jour. Myc. 4: 100. 1888) and *H. subrubescens* Rehm (Ann. Myc. 7: 524. 1909).

PHIALEA ANOMALA Peck, Rep. N. Y. State Bot. for 1912. N. Y. State Mus. Bull. 167: 29. 1913. = *Rutstroemia longipes* (Cooke & Peck) White, Lloydia 4: 203. 1941. The apothecia are on stromatized petioles of *Fraxinus*; not on "dead herbaceous stems or twigs" as indicated by Peck.

## OLD EUROPEAN SPECIES REPORTED BY PECK FOR NEW YORK

*Helotium herbarum* (Pers. ex Fries) Fries: *Peziza cyathoidea* Bull. = *Helotium cyathoidcum* (Bull. ex Fries) Karst.; *Peziza citrina* Batsch. = *Helotium citrinum* (Hedw. ex Fries) Fries; *Helotium epiphyllum* (Pers. ex Fries) Fries; *Helotium aciculare* Fries = *Cudoniella aciculare* (Bull. ex Fries) Schröt.; *Helotium salicellum* (Fries) Fries; *Helotium lutescens* (Hedw. ex Fries) Fries. No attempt has been made to systematically examine Peck's collections of these species, but all represent species which are of common occurrence in the state.

The writer wishes to thank Dr. D. H. Linder for aid rendered in various ways, and Prof. H. M. Fitzpatrick of Cornell University, Dr. Homer D. House of the New York State Museum, and Dr. Fred J. Seaver of the New York Botanical Garden for making available material and facilities for study at their respective institutions.

HARVARD UNIVERSITY,  
CAMBRIDGE, MASSACHUSETTS

# STUDIES ON SOME CALIFORNIA FUNGI II

LEE BONAR

(WITH 2 FIGURES)

The following descriptions of new species and notes on known species represent some of the accumulations of recent years that are considered worthy of notice.

DERMATEA BRUNNEO-PRUINOSA Zeller, Mycologia 26: 291. 1934.

*Pestalozzia (Pestalotia) gibbosa* Harkness, Bull. Calif. Acad. 2: 439. 1887.

The *Pestalotia* leaf spot on *Gaultheria Shallon* Pursh has been found commonly near the coast in northern California and Oregon for many years. Zeller described the discomycete occurring in the same spots with the *Pestalotia*, and suggested that because of the close association of the two forms there was probably an organic connection between them. Leaves bearing the two forms were collected at Trinidad, California, by H. E. Parks. Cultures were grown in the laboratory, from single ascospores of the *Dermatea* and from single conidia of the *Pestalotia*. The two series were grown on a number of common laboratory media and were found to be indistinguishable in growth characters. Sporulation was sparse or lacking on media used, except on oat-meal agar where it was abundant, forming the conidia typical for *Pestalotia gibbosa* in both series, thus proving that the two forms were stages in the life cycle of one organism. No apothecia were obtained in the laboratory cultures.

An interesting relation between temperature and the development of the fungus was observed. Cultures were grown in five different temperature chambers ranging from 8-30° C. Growth was optimum at 15-17° C., while it was markedly reduced at either lower or higher temperatures. Spore formation occurred only in those cultures that were grown at the optimum temperature. This cor-

relates well with the development of the fungus in nature, since it is found along the coastal region where the temperatures are relatively low for a considerable portion of the year.

Culture work on this fungus was carried out by Dr. Paul Harvey.

**Haematomyxa Sequoiae** (Plow.) comb. nov.

*Cenangium Sequoiae* Plow. Grevillea 7: 23. 1878.

*Scleroderris Sequoiae* (Plow.) Sacc. Syll. Fung. 8: 596. 1889.

The original description appeared in "Fungi of California" by Wm. Phillips: "Gregarious, turbinate, black, margin connivent; disc black, pale, cinerous within; asci broadly clavate; sporidia 8, ovate, or ovate-oblong, simple, or triseptate, enucleate,  $.025-.03 \times .007-.015$  mm.; paraphyses slender, furcate. On *Sequoia gigantea*, No. 639."

Emended description: apothecia gregarious or solitary, erumpent, often becoming superficial, turbinate, black, gelatinous when fresh, horny when dry, externally smooth, reaching a diameter of two mm. (FIG. 2, *a*); excipulum extending beyond the hymenium and incurved, outer layers black, colorless within; hymenium fuscous; asci broadly clavate, wall thickened above,  $240-300 \times 60-80 \mu$ , eight spores; spores ellipsoidal, or slightly asymmetric, fuscous, muriform, with seven transverse septa, slightly constricted at heavier median septum, two to three seriate in ascus,  $60-80 \times 20-30 \mu$ ; asci and spores vary greatly as to size and maturity in a single hymenium. Paraphyses abundant, much branched above, and the tips colored to form a dark epithecium (FIG. 1, *e*). In the bark of fallen branches of *Sequoia* in California.

Material examined: on *Sequoia gigantea* (Lindl.) Dec.: Big Trees, Calif. Herb. Calif. Acad. Sciences, Harkness No. 639X; two from Yosemite National Park; Tuolumne Grove, June 1933, and Mariposa Grove, May 1934, Lee Bonar; Sequoia National Park, July 1934, H. E. Bailey; on *Sequoia sempervirens* (Lamb.) Endl.: Bolling Grove, Humboldt Co., July 1933, Lee Bonar.

Efforts to learn the location of the type material of Plowright have failed, but scant material preserved in the California Academy of Sciences Herbarium is numbered 639X and notes in Harkness' handwriting designate it as a portion of the collection sent to Plowright and published through Phillips. This material of the Harkness collection corresponds in all features with the recent collec-

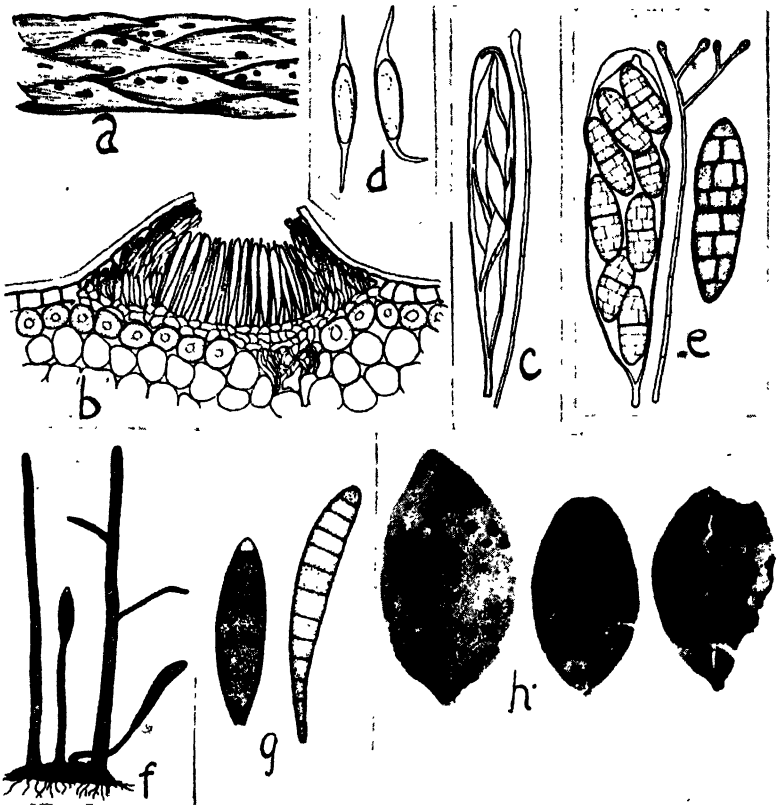


FIG. 1. *a-d*, *Pezizella aristospora*: *a*, apothecia in leaves, *b*, structure of apothecium in section, *c*, ascus and paraphysis, *d*, ascospores; *e*, *Haematomyxa Sequoiae*: ascus, paraphysis and ascospore; *f-g*, *Chaetotrichum macrosporum*: *f*, setae and conidia, *g*, two types of conidia; *h*, *Strumella Simmondsiae*: habit on leaves,  $\times \frac{1}{2}$ .

tions, and examination of immature stages in the latter shows the same characters given in the original description. It is obvious therefore that the description was drawn from immature material.

Pure cultures grown from single ascospores in the laboratory failed to show any conidial stage of reproduction. Cultures grown on sterilized twigs of *Sequoia* in test tubes developed apothecia which formed asci and spores after four to five months.

I am indebted to Dr. F. J. Seaver for assistance in the study of this species.

***Pezizella aristospora* sp. nov.**

Apothecia dispersa, solitaria, intra-epidermalia, per cuticulam crassam irregulariter erumpentia, orbicularia vel elliptica, 0.5–1 mm. diam., in humido cupularia et molliter ceracea, in sicco cornea, margine involuta; excipulum tenue, molle, leve, prosenchymaticum, superficie externa fusca (apicibus hypharum plus minusve parallelarum fuscobrunneis), marginem supra hymenium fusco-carneum paulo extendentem constituens; hypothecium tenue, parenchymaticum, hyalinum; asci cylindraneo-clavati, ad apicem obtusati,  $95\text{--}110 \times 10\text{--}12\ \mu$ , apices iodo caeruleis nontinctis, octosporii, sporidia uniseriata vel biseriata, continua, levia, hyalina, attenuato-fusoidea, apicibus longe apiculiformibus, recta vel paulum arcuata, 1 vel 2 guttis,  $20\text{--}25 \times 4\text{--}5\ \mu$ ; paraphyses multae, ascos aequiparantes vel superantes, apicibus usque ad  $3\text{--}5\ \mu$  tumifactis, achromaticae, pariete gelatinoso.

Apothecia scattered, single, intra-epidermal, erumpent, the heavy cuticle breaking irregularly, circular to elliptic, 0.5–1 mm. in diameter, soft waxy and cupshaped when moist, horny when dry, margin inrolled when dry (FIG. 1, *a*); excipulum thin, soft, smooth, prosenchymic, the tips of the more or less parallel hyphae dark brown, making the outer surface fuscous, extending somewhat as a sterile margin above the dark flesh-colored hymenium, hypothecium thin, parenchymic, hyaline (FIG. 1, *b*); asci cylindric-clavate, obtuse above,  $95\text{--}110 \times 10\text{--}12\ \mu$ , tips not blue with iodine, 8-spored, spores uniseriate to biseriata; spores 1-celled, smooth, hyaline, attenuated-fusoid, one or two oil drops,  $20\text{--}25 \times 4\text{--}5\ \mu$ , tips extended as elongate apiculi, straight or somewhat curved; paraphyses numerous, equaling or exceeding the asci, tips enlarged to  $3\text{--}5\ \mu$ , colorless, with a gelatinous wall (FIG. 1, *c*, *d*).

In dead leaves, small fallen twigs, *Sequoia gigantea* (Lindl.). Dec., Tuolumne Grove, Yosemite National Park, California, July 23, 1933, Lee Bonar, type, Univ. Calif. Herb. 653847.

***Clithris Sequoiae* sp. nov.**

Hysterothecia atra, in ligno patenti aut per corticem erumpentia, saepe confluentia et in ligno strias longas atras formantia, valde carbonacea, lincaria vel oblongo-linearia, ad extremitates acuta, lateraliter applanata, usque ad 5 mm. longa, 0.2–0.5 mm. lata, ad 0.8 mm. alta, rima longa irregulari aperta sine labiis distinctis vel periphysibus; asci angusti, cylindranei vel subclavati, superne rotundati vel subacuti, ad pedicellum longum tenuem, attenuati,  $90\text{--}120 \times 6.5\text{--}8\ \mu$ , tetra vel octospori; sporidia hyalina, acicularia, sine septis, recta vel inasco paulo torta, plus minusve fasciculata, superne obtusata et ad basin plus minusve attenuata, magnitudinis variae, plerumque  $50\text{--}55 \times 0.75\text{--}1.25\ \mu$ , inasco sporidia in matrice tenui gelatinosa (quae in sporidiis solitis non manifesta) tunicata; paraphyses non clavatae, varie geniculatae vel compressae, filiformes, simplices, hyalinae,  $83\text{--}135 \times 1\text{--}1.5\ \mu$ .



Hysterothecia dull black, on exposed wood or erumpent through bark, often confluent and forming long black striae on wood, heavily carbonized, linear or oblong linear, acute at ends, laterally compressed, up to 5 mm. long, 0.2–0.5 mm. wide, up to 0.8 mm. high, opening by a long irregular slit, without distinct labia or periphyses; asci narrow, cylindric to sub-clavate, rounded to sub-acute above, tapering from above middle to a long slender stalk,  $90\text{--}120 \times 6.5\text{--}8 \mu$ , 4 or 8 spored; spores hyaline, needle-like, non-septate, straight or somewhat twisted in ascus, more or less in fascicles, rounded above and tapering toward the base, varying in length, chiefly  $50\text{--}55 \times 0.75\text{--}1.25 \mu$ , in ascus apparently incased in thin gelatinous matrix, which is not evident on free spores; paraphyses not clavate, variously bent or crushed above, filiform, simple, hyaline,  $85\text{--}135 \times 1\text{--}1.5 \mu$ .

On dead branches of *Sequoia sempervirens* (Lamb.) Endl., Trinidad, Humboldt Co., California, Nov. 1931, H. E. Parks 4020, type, Univ. Calif. Herb. 653855. Same locality, March 1932, Parks 3392, Feb. 1939, Parks 4639.

This species is very near to *Clithris crispa* (Pers.) Rehm, but differs from this in its longer and narrower hysterothecia, the larger asci and the clavate narrow spores.

I am indebted to Dr. L. R. Tehon for assistance in the study and description of this material.

### **Mycosphaerella Sequoiae** sp. nov.

Perithecia multa, hypophylla, raro epiphylla, dispersa, solitaria vel crebra, subepidermalia, globosa, ostiolo brevi papilliformi erumpentia,  $90\text{--}125 \mu$  diam., pariete carbonaceo,  $10\text{--}20 \mu$  crasso; asci fasciculati, elongato-cylindracei, superne paulum angustati, breviter stipitati, octospori,  $50\text{--}60 \times 10\text{--}12 \mu$ ; ascospordia fusiformi-elliptica, hyalina, bicellularia,  $11\text{--}14 \times 3\text{--}4 \mu$ , cellula basilaria paulum angustata, cellulis pariter longis; paraphyses nullae.

Perithecia numerous, hypophyllous, rarely epiphyllous, scattered, single or clustered, subepidermal, globose, erumpent by a short papillate ostiole,  $90\text{--}125 \mu$  diameter, wall carbonaceous,  $10\text{--}20 \mu$  thick; asci fasciculate, elongate-cylindric, slightly narrowed above, short stipitate, 8-spored  $50\text{--}60 \times 10\text{--}12 \mu$ ; ascospores fusiform-elliptic, hyaline, 2-celled,  $11\text{--}14 \times 3\text{--}4 \mu$ , basal cell somewhat narrowed, cells of equal length; paraphyses none.

On leaves and young twigs of *Sequoia sempervirens* (Lamb.) Endl., Trinidad, Humboldt Co., California, H. E. Parks, spring 1932, type, Univ. Calif. Herb. 653844, Feb. 1, 1933.

Infection starts at the tips of the leaves and progresses to the base. High percentage of the leaves often killed, giving the mass of foliage a blasted appearance.

**Phaeosphaerella Rhamni** sp. nov.

Maculae amphigenas irregulares, 1–2 cm. diam., pallide brunneae, margine castaneo, fuscantes in maturitate perithecorum et reticulantes cum hyphis brunneis sub cuticula; perithecia dispersa vel aggregata, epiphylla, subepidermalia erumpentia, globosa, 100–125  $\mu$  diam., ostiolo poroideo, pariete membranaceo; asci octospori, fasciculati, cylindracei, breviter stipitati, 42–45  $\times$  9–10  $\mu$ ; sporidia uniseriata vel biseriata, ellipsoidea, bicellularia, non constricta, olivacea, 11–14  $\times$  4–5  $\mu$ , cellula inferna paulo angustata; paraphyses nullae.

Spots amphigenous irregular 1–2 cm. diameter, light brown with a reddish-brown border, becoming darker with the production of perithecia and reticulate with the development of brown hyphae under the cuticle; perithecia scattered to crowded, epiphyllous, subepidermal, erumpent, globose, 100–125  $\mu$  diameter, ostiole poroid, wall membranaceous; asci 8-spored, fasciculate, cylindric, short-stipitate, 42–55  $\times$  9–10  $\mu$ ; spores uniseriate or biseriate, 2-celled ellipsoidal, non-constricted, olivaceous, 11–14  $\times$  4–5  $\mu$ , lower cell somewhat narrowed; paraphyses none.

Parasitic on living leaves of *Rhamnus californica* Esch., 18 Mile Creek, Smith River, Del Norte County, California, type, Univ. Calif. Herb. 653842, July 13, 1933, Lee Bonar and H. E. Parks.

**Diedickeia Piceae** sp. nov.

Pycnidia amphigena, dispersa vel crebra, omnino superficialia, in subiculo tenuissimo et ab folii pagina facile separante disposita; subiculum reticulum tenue ex hyphis tenuis hyalinis et raris crassioribus brunneis textum; pycnidia disciformia, radiata, ostiolo nullo, in maturitate stellate dehiscentia, 200–400  $\mu$  diam., strato externo fusco vel atro, strato basilari obscuro ex hyphis tenuis hyalinis texto; conidia elliptica, hyalina, continua, 2.5–3.5  $\times$  1  $\mu$ , in massis mucosis adhaerentia; conidiophora nulla.

Pycnidia amphigenous, scattered or crowded, entirely superficial, borne on an extremely thin subiculum which separates readily from the leaf (FIG. 2, b); subiculum of a thin meshwork of fine hyaline hyphae with occasional larger brown hyphae; pycnidia disciform, radiate, non-ostiolate, opening at maturity by stellate dehiscence, 200–400  $\mu$  diameter, outer layer fuscous to black, basal layer indistinct, of fine hyaline hyphae; conidia elliptic, hyaline, 1-celled, 2.5–3.5  $\times$  1  $\mu$ , clinging together in mucoid masses; conidiophores none.



FIG. 2. *a*, *Haematomyxa Sequoiae*, apothecia in bark,  $\times 7$ ; *b*, *Didickia Piceae*, pycnidia on leaves,  $\times 10$ ; *c*, *Peziza ochracea*, apothecia.

On leaves of *Picea sitchensis* (Bong.) Carr., Trinidad, Humboldt County, California, May 1931, H. E. Parks 3890, type, Univ. Calif. Herb. 653851; Nov. 1932, Parks 4059.

The fungus causes yellowing and discoloration of the leaves and early leaf fall. It appears on the current season's foliage in the autumn, and becomes conspicuous on these leaves the following summer. As the leaves become yellowed, the pycnidia separate from the leaf and fall off.

This species has a more delicate subiculum than that described and figured for the type species of the genus by Sydow (Ann. Myc. 11: 268-269. 1913.) but the structure of the pycnidia, the manner of dehiscence, the mucoid nature of the spore masses, and the lack of conidiophores place it within the genus.

### ***Dothichiza Garryae* sp. nov.**

Maculae primo parvae, denique maiores et confluentes, saepe totum folium occupantes, cinereo-brunneae, margine purpureo; pycnidia amphigena, plerumque epiphylla, dispersa solitariaque, subepidermalia, denique plus minusve superficialia cuticulis levatis, 200-325  $\mu$  diam., pariete sclerotioideo, 30-40  $\mu$  crasso, operculo plano, deplapso in sicco, ex cuticula folii nigrescente constituto, decidente; conidia cupulae pycnidii ubique superficiem internam occupantia, cylindraceo-ellipsoidea, hyalina, continua, 14-20  $\times$  3.5-4.5  $\mu$ ; conidiophora brevissima vel obsoleta.

In spots, small at first, becoming larger and confluent, often involving the entire leaf, cinereous brown with a purplish border; pycnidia amphigenous, mostly epiphyllous, scattered, single, subepidermal, becoming semisuperficial by lifting of the cuticle, 200-325  $\mu$  diameter; pycnidial wall of sclerotial tissue, 30-40  $\mu$  thick, lid flat, sunken when dry, consisting of cuticle of the host somewhat blackened, and falling away in dehiscence leaving an open cupulate chamber; conidia borne on entire inner surface of the chamber, cylindric-ellipsoid, hyaline, continuous, 14-20  $\times$  3.5-4.5  $\mu$ ; conidiophores extremely short or obsolete.

On living or dead leaves of *Garrya elliptica* Dougl., San Rafael Hills, Marin Co., Calif., Jan. 1925, Lee Bonar, type, Univ. Calif. Herb. 653856; near summit Mt. Tamalpais, Marin Co., Calif., March 13, 1926, Lee Bonar.

On leaves of *Garrya flavescens* Wats. var. *buxifolia* Jepson, 18 Mile Creek, Smith River, Del Norte Co., Calif., July 13, 1933, Lee Bonar and H. E. Parks.

**Phyllosticta Phoradendri** sp. nov.

Maculae orbiculares vel irregulares vel confluentes, brunneae, medio fusco; pycnidia tarde apparentia in regionibus mortuis, amphigena, crebra, subepidermalia, erumpentia, globosa, 125–200  $\mu$  diam., poroideo ostiolo, membranaceo pariete, atra; conidiophora simplicia, brevissima; sporidia bacilliformia, hyalina, continua,  $2-3.5 \times 1 \mu$ .

Spots circular to irregular or confluent, brown with dark center; pycnidia appearing tardily in dead areas, amphigenous, crowded, subepidermal, erumpent, globose, 125–200  $\mu$  diameter; ostiole poroid; wall membranaceous, black; conidiophores simple, very short; spores bacilliform, hyaline, 1-celled,  $2-3.5 \times 1 \mu$ .

In leaves of *Phoradendron flavescens* Nutt. var. *macrophyllum* Engelm. on *Populus* sp., causing conspicuous killing of the leaves. Near Onyx, South Fork Kern River, Kern County, California, March 30, 1933, Lee Bonar, type, Univ. Calif. Herb. 653839.

**Cercospora californica** sp. nov.

Maculis sparsis, interdum confluentibus, ad 5 mm. diam.; brunneis ad fuscis, caespitulis hypophyllis albidis; mycelio superficiali nullis; conidiophoris fasciculatis, simplicis, brevibus, nonseptatis, hyalinis,  $15-20 \times 4-5 \mu$ , erumpentibus ex stromatis tuberculatis, subhyalinis; plerumque hypophyllis; conidiis cylindricis vel angustis-obclavatis, 6–8 (12) septatis, hyalinis, rectis vel curvatis,  $40-70 (90) \times 3-4 \mu$ .

Spots scattered, sometimes confluent, up to 5 mm. diameter, brown to fuscous, white tufted below, superficial mycelium none; conidiophores fasciculate, simple, short, non-septate, hyaline,  $15-20 \times 4-5 \mu$ , erumpent from tuberculate, subhyaline stromata; mostly hypophyllous; conidia cylindric or narrow obclavate, 6–8 (12) septate, hyaline, straight or slightly curved,  $40-70 (90) \times 3-4 \mu$ .

On living leaves of *Rhus diversiloba* Torr. & Gray in California. San Mateo Co., Aug. 15, 1935, Lee Bonar, type, Univ. Calif. Herb. 653836; Monterey Co., Aug. 1935, 1937, Lee Bonar; Pasadena Aug. 1894, McClatchie, distributed in Fungi Columbani No. 691 as *Cercospora Toxicodendri* Ellis.

This species differs from *Cercospora ruina* Cooke & Ellis in the white flocculent surface of the fertile portions of the spots, and in the conidiophores which are simple, much shorter and distinctly hyaline, and in the hyaline conidia.

**Chaetotrichum macrosporum** sp. nov.

Mycelium in superficie ramulorum mortuorum maculas parvas formans vel continuum usque ad nonnulla cm.; hyphae superficiales vel corticem mortuum penetrantes, fuscae, nodosae irregularesque, ramosae; setae ex pulvinis hypharum basilarium erectae, dispersae vel saepius crebrae, tegeticulum atram formantes, rigidae, plerumque simplices, interdum ramosae, ad apicem obtusae, usque ad 1 mm. longae, 10–20  $\mu$  diam., breviores saepe in vertice sporam ferentes; hypharum basilarium rami immutati frequenter inverticibus sporas typo alio singillatim ferentes; sporae ramorum setosorum fusoido-ellipticae, fuscae, septis 5–6, parietibus crassis, cellula terminali subhyalina, 30–40  $\times$  10–14  $\mu$ ; sporae ramorum hyphae immutatorum clavatae, fuscae, septis 8–12 (16), rectae vel paulo curvatae, ad basin valde attenuatae, ad apicem obtusatae, 50–125  $\times$  12–22 (plerumque 75–90  $\times$  15–18)  $\mu$ , magnitudine et septis maxime variis.

On surface of dead twigs, in small spots or continuous over surface for several centimeters; hyphae on surface or penetrating dead bark, fuscous, gnarled and irregular, much branched; setae erect from cushions of basal hyphae, scattered or more commonly crowded to form a black mat, rigid, usually simple, obtuse at tip, up to 1 mm. long by 10–20  $\mu$  diameter, shorter ones frequently bearing a spore at the tip, undifferentiated branches of basal hyphae frequently bear a second type of spore singly at tips; spores on setose branched fusoid-elliptic, fuscous, 5–6 septate, thick-walled, terminal cell sub-hyaline, 30–40  $\times$  10–14  $\mu$ ; spores on simple hyphal branches clavate, fuscous, 8–12 (16) septate, straight or somewhat curved, strongly attenuated toward base, distal end obtuse, 50–125  $\times$  12–22 (av. 75–90  $\times$  15–18)  $\mu$ , very variable as to size and septation (FIG. f, g).

On dead twigs of woody angiosperms, coastal California. Trinidad, Humboldt Co., California: on *Gaultheria Shallon* Pursh, May 10, 1931, H. E. Parks, type, Univ. Calif. Herb. 653859, *Myrica californica* Cham., Jan. 1932, Parks 4043, *Physocarpus capitatus* (Pursh) Ktze., Parks 4033, and *Rubus spectabilis* Pursh, April 1932, Parks 4039. Berkeley California: on *Prunus* sp., April 2, 1933, D. M. Brenneman.

The genus *Chaetotrichum* was erected by Sydow (Ann. Myc. 25: 150. 1927). The type species *C. Solani* was described from living leaves of *Solanum* from Costa Rica. Our material agrees well with the generic characters listed by Sydow, but is distinct because of its habitat and variations in spore forms.

**Strumella Simmondsiae** sp. nov.

Maculis effusis, amphigenis, orbiculatis, depressis, atris, 1-4 mm. diam., cum marginibus distinctis, angustis, pallidis; sporodochiis minutis, tuberculatis, in pseudostromate hyphis fuscis, compactis, irregulariter ramosis; hyphis 4-6  $\mu$  diam.; conidiis raris, subglobosis, fuscis, minutis verrucosis, 7-10  $\times$  5-7  $\mu$ ; simpliciter cellulis rotundis, a hyphis irregulariter formatis.

Spots scattered, amphigenous, circular, depressed, black, 1-4 mm. diam., with a distinct, narrow, light margin (FIG. 2, *h*); sporodochia minute, tuberculate on a pseudostroma of compact, irregularly branched, dark brown hyphae; hyphae 4-6  $\mu$  diam.; conidia rare, subglobose, fuscous, minutely verrucose, 7-10  $\times$  5-7  $\mu$ , simply rounded cells, irregularly formed from hyphae.

On living leaves, calyxes, and peduncles of *Simmondsia californica* Nutt., southern California, Arizona, and Lower California. Riverside Co., California: south of Hemit, H. S. Fawcett, May 7, 1939, type, Univ. Calif. Herb. 653866. Aguanga, Fred Reed, Aug. 20, 1938, H. S. Fawcett, June 23, 1940.

Phanerogamic specimens of the host in the Dudley Herbarium, Stanford University, showed typical spots of this fungus on the following collections: San Diego Co., Calif.: Pampoto Mt. Springs, H. E. McMinn 1258; Oneonota, A. C. Herre; Cottonwood Creek Valley, J. T. Howell 2968; Sweetwater Dam, Geo. B. Grant; Otay River Wash, I. L. Wiggins 3243; C. Epling and W. Robinson. Arizona: Tucson, I. L. Wiggins 6504; Superstition Mts., Pinal Co. 8838, and Apache Gap, Maricopa Co. 8807, G. W. Gillespie; Santa Catalina Mts., J. J. Thombert 298. Lower California: San Quintin, C. Epling and Wm. Stewart; Agua Caliente, S. B. and W. F. Parish 9.

**PHYSALOSPORA ILICIS** (Schleich.) Sacc.

Collections of dead twigs of *Ilex aquifolium* L. made at Berkeley, California, were found to bear reproductive structures of three different fungi: *Physalospora Ilicis* (Schleich.) Sacc., *Macrophoma ilicella* (Sacc. & Penz.) Berl. & Vogl., and *Phoma ilicina* Ellis & Anderson. Since a number of imperfect forms have been suspected of being the conidial stage of *Physalospora Ilicis*, studies were undertaken to determine what possible relationship might exist between the three forms found growing on the same twigs. Single spore isolations were made of the three types and the

cultures were grown under similar conditions on a variety of culture media. It was very soon apparent that the cultures from single ascospores of *Physalospora Ilcis* and those from single conidia of *Macrophoma ilicella* were indistinguishable when grown under similar conditions as to culture media and external conditions. The cultures from conidia of *Phoma ilicina* were distinctly different in appearance and habit of growth.

Cultures of the *Physalospora* and *Macrophoma* developed pycnidia with abundant conidia in twenty to twenty four days, most abundant on oatmeal agar. Extensive culturing and variations in the media and conditions under which the cultures were grown failed to produce the perithecial stage in cultures, but the consistent production of the *Macrophoma* stage proves that these two are stages in the same fungus. The distinctly different cultures and the production of typical pycnidia of *Phoma ilicina* likewise prove that it is not part of the life cycle of *Physalospora Ilcis*.

#### SPHAERULINA MYRIADEA (DC.) Sacc.

Parasitic on leaves of *Castanopsis sempervirens* Dudley, Sequoia National Park, California, H. E. Parks, June 1931. Causes conspicuous brown spotting of the leaves with numerous perithecia formed in the upper side of the leaves. This extends the known host range for this fungus.

#### BONORDENIELLA MEMORANDA Penz. & Sacc.

On dead flower stalks and capsules of *Agave deserti* Engelm. Mt. San Jacinto, Riverside Co., California, February 1938, H. E. Parks 6183. This material agrees well with the original description and illustrations (Ic. Fung. Jav. tab. 80, f. 4) except that the conidiophores in this material are more irregular and torulose, whereas that from Java is described and figured as having longer and more regular conidiophores. This collection records a new locality and substratum for this species.

#### PEZIZA OCHRACEA Boud.

Scattered to slightly caespitose on clay soil under *Quercus agrifolia* Nee, Berkeley, California, D. G. Nelson, March 9, 1938 (FIG. 2, c).



This European species does not seem to have been reported from North America, but our material agrees well with Cooke's description. The suggestion by Bresadola (Icon. Myc. 25: 1205) that this species be considered as a synonym of *Peziza pustulata* (Aleuria) (Hedw.) Pers. appears unjustified on the basis of the characters of both the spores and paraphyses.

**POLYPORUS SULPHUREUS (Bull.) Fries.**

This species has been found rather frequently during late summer and early autumn on stumps and bases of living trees of *Eucalyptus globulus* Labill. in central California. Extensive heart rot is caused in the lower trunk and large roots. One specimen was observed which matured in 15 days after emergence. In that time it developed into a three-tiered sporophore  $12 \times 18$  inches, and weighed eight pounds when fresh. This fungus was reported on *Eucalyptus globulus* Labill. and *Eucalyptus amygdalina* Schau. in Argentina by C. Spegazzini. (Bol. Acad. Nac. Ci. Cordoba 28: 267-406. 1926.)

**ENTYLOMA MELILOTI McAlpine.**

Collected on *Melilotus indica* All., Monterey Co., California, J. M. Linsdale, May 24, 1941. This represents an extension of the known distribution of this species in the United States, earlier reports having recorded it from Alabama and Louisiana.

**TROCHILIA ILCIS (Chev.) Crouan.**

Collected on diseased or dead leaves of *Ilex Aquifolium* L., Eureka, Oct., 1933, Parks and Tracy 13108, and Berkeley, California, Nov., 1940, Lee Bonar. This species is widely reported from Europe but apparently not common in America. It has been commonly listed and distributed as *Stegia Ilcis* Fries. The paraphyses are not the elongated, pointed type characteristic of the genus *Stegia*, but are the abruptly swollen type of *Trochilia*. Rehm (Rab. Krypt. Fl. 13: 129-130.) has given the synonymy of *Trochilia Ilcis* (Chev.) Crouan and has pointed out the fact that *Trochilia Ilcis* Fries does not belong here.

# A SYNOPSIS OF ROZELLA AND ROZELLOPSIS

JOHN S. KABLING

In a previous paper on parasitism among chytrids, the author (1942) presented some of the developmental, cytological, and systematic problems which remain to be solved in relation to *Rozella*, and described three new species of this genus which attack chytridaceous fungi. In an attempt to clarify the taxonomic difficulties which have arisen from the discovery of new species since Cornu's and Fischer's times, a new genus, *Rozellopsis*, was proposed for the *Rozella*-like species with biflagellate, heterocont zoöspores. *Rozella* was retained in the original sense of Cornu for the posteriorly uniflagellate species, and *Plecolpidium* was reduced to the status of a synonym, as had been previously suggested by Sparrow (1938). Inasmuch as the number of *Rozella* parasites has increased considerably in the last decade and the descriptions of them are widely scattered in the literature, it is worth while for the sake of future studies to classify these species in light of present day knowledge and bring them together in one paper. The present contribution relates primarily to diagnoses of the known species of *Rozella* and *Rozellopsis* and presents again many of the problems which must be solved before these genera can be properly classified.

Differences in development between the monosporangiate and polysporangiate species of *Rozella* and their respective effects on the host have been recognized by all students of this genus. As early as 1872 Cornu showed that *R. Monoblepharidis*, *R. Rhipidii*, and *R. Apodyae* cause local hypertrophy of the host and asserted that their thalli form only one sporangium or resting spore. *Rozella septigena*, on the other hand, causes slight or no hypertrophy but induces septation of the infected hyphae. Its thallus, Cornu believed, functions as a sorus or plasmodium and divides into a number of segments which become separated by the host

septa, mature in basipetal succession, and develop into sporangia or resting spores. Fischer (1882) likewise noted and emphasized these differences but reported that the zoöspores of *R. septigena* and *R. simulans* are biflagellate and heterocont instead of posteriorly uniflagellate. He did not, however, attach so much significance to the number and position of the flagella as to the differences in development and effects on the host, and classified the species into two groups on the latter basis. Cornu's three monosporangiate species were placed in the "Sporangiumgruppe," while *R. septigena* and *R. simulans* were included in the "Septigenagruppe." Fischer later (1892) created a new genus, *Pleolpidium*, for the species of the first group, and limited *Rozella* to the members of the "Septigenagruppe" with *R. septigena* as the type species. In so doing he violated the rules of priority, as Sparrow has already pointed out, since *R. Monoblepharidis* was the first species described and must accordingly be accepted as the type species of the genus. Nevertheless, Fischer's classification of the species and his interpretation of *Pleolpidium* and *Rozella* were followed by most mycologists, who, however, emphasized the number, position, and relative lengths of the flagella as well as differences in development of the thalli.

Foust's (1937) discovery of a posteriorly uniflagellate septigenous species in *Allomyces* and the present author's recent observations of a similar species in *Achlya* sp., on the other hand, indicate that Cornu was correct in his account of the zoöspores of *R. septigena* and that Fischer was either wrong or had a different species at hand. As a consequence of Foust's discovery, Sparrow (1938) and the author (1942) have advocated the retention of *Rozella* in the original sense of Cornu, with *Pleolpidium* as a synonym. This reintroduces the problem of classification within the genus on the basis of differences in development and effects on the host. Sparrow revived Fischer's groups by translating the terms into English—i.e., sporangium-group and septigena-group. Inasmuch as one of these terms refers to sporangia and the other to segmentation of the thallus and the effects on the host, they are not comparable and give the impression that sporangia are formed in one group and not in the other. There is obviously need here for more descriptive terms. The adjective nonseptigenous is more

appropriate than the term sporangium-group and may be profitably substituted. Monosporangiate and polysporangiate are other purely descriptive terms, which are non-committal as to whether or not the thallus undergoes segmentation.

The question of whether or not the thallus segments into several portions has not been conclusively settled. All students of the septigenous species have followed Cornu's belief and have expressed the opinion that the thallus is a sorus or plasmodium which cleaves into a number of segments which in turn become separated by host walls, mature in basipetal succession, and form sporangia. Although observations on living material strongly suggest this type of development, it has not been conclusively proven. If it should prove to be generally characteristic of the septigenous species, they will probably have to be segregated in a new genus. In our present state of knowledge, however, it is perhaps wiser to include them in *Rozella* with the monosporangiate species. This genus is accordingly presented in the original sense of Cornu and includes two groups of species. On the basis of its posteriorly uniflagellate zoöspores and intramatrical, holocarpic sporangia, it is provisionally included in the family Olpidiaceae. Further study of the septigenous members of the genus, however, may necessitate their removal from this family.

A new genus, *Rozellopsis*, was proposed by the author (1942) for the biflagellate, heterocont, *Rozella*-like species which have been reported in the literature from time to time. It was created primarily to include *Pleolpidium inflatum* Butler and a similar species which Miss Waterhouse (1940) found in *Phytophthora*. Both of these species appear to be monosporangiate and non-septigenous and fill the hypertrophied host cells so completely that their walls are indistinguishable from those of the host. However, nothing is known about their resting spores, and it is accordingly impossible to determine their relationship to other species.

Whether or not Fischer's biflagellate, heterocont *R. septigena* and *R. simulans* also belong in *Rozellopsis* is highly questionable. Tokunaga (1933) confirmed Fischer on the number and relative lengths of the flagella in *R. simulans*, which indicates the existence of septigenous species with zoöspores of this type. For this reason Fischer's *R. septigena* has been separated from Cornu's species of

the same name and is included with *R. simulans* provisionally in this genus. *Rozellopsis*, like *Rozella*, thus includes at present two groups of species. Its relation to other genera is uncertain, but for the time being it may be placed in the family Woroninaceae, which appears at present to be scarcely more than a dumping ground for biflagellate heterocont species. This interpretation is of course only temporary. Since all of its species are either doubtful or imperfectly known, further studies will doubtless invalidate many of the present day concepts.

ROZELLA Cornu, Ann. Sci. Nat. V. 15: 150. 1872..

*Pleolpidium* A. Fischer, Rab. Krypt.-Fl. 1<sup>4</sup>: 43. 1892.

Thallus intramatrical, holocarpic, more or less indistinguishable from but apparently immiscible with the host protoplasm; becoming invested with wall at maturity and forming one sporangium or resting spore, or cleaving (?) into several segments which become separated by host walls, mature in basipetal succession, and develop into sporangia or resting spores. Sporangia variable in size and shape, terminal or intercalary, hyaline and smooth, with one to six prominent or inconspicuous exit papillae which extend through the host wall; usually filling the host cell or hypertrophied portion of host hyphae completely; sporangium wall tightly pressed against, seemingly fused with, and usually indistinguishable from that of the host. Zoöspores numerous, hyaline, pyriform, ellipsoidal, and obclavate, with or without one to several minute globules; posteriorly uniflagellate, occasionally bi- and multiflagellate; flagellum approximately 4 to 6 times as long as spore body; usually swirling in the sporangium before emerging fully formed and swimming away; motility rapid, jerky and darting; contents flowing into host cell through an infection tube during germination, leaving the empty zoöspore case on the outside. Resting spores numerous or solitary in host cell, variable in size, shape, and color, smooth, warty or spiny; usually formed in the same portions of the host as the zoösporangia but lying free within and separate from the host wall; protoplasm coarsely granular with a large central vacuole or globule of hyaline substance; producing zoöspores directly in germination.

#### NONSEPTIGENOUS, MONOSPORANGIATE SPECIES

ROZELLA MONOBLEPHARIDIS Cornu, l.c., 148. pl. 4, fig. 13-18.

*Pleolpidium Monoblepharidis* A. Fischer, Rab. Krypt.-Fl. 1<sup>4</sup>: 44. 1892.

Sporangia intercalary in host hyphae, ovoid, truncate, or barrel-shaped with one short exit papilla; wall distinct from that of host at ends of sporangia. Zoöspores unknown. Resting spores spherical, spiny, and brown; contents coarsely granular, including a large central refractive globule; germination unknown.

Parasitic in *Monoblepharis polymorpha* in France (Cornu, l.c.) and Germany (Minden, 1911), causing large local swellings in the mycelium.

This is the type species of *Rozella* and has been reported but once since Cornu's time. Nothing is known about its zoöspores or the dimensions of the sporangia and resting spores.

ROZELLA RHIPIDII Cornu, l.c., p. 153. *pl. 5, fig. 1-9.*

*R. Rhipidii spinosa* Cornu, l.c.

*Pleolpidium Rhipidii* (Cornu) A. Fischer, Rab. Krypt.-Fl. 1<sup>4</sup>: 44. 1892.

*P. Ariosporae* (Cornu) Minden, Krypt.-Fl. Mark Brand. 5: 252. 1911.

Sporangia terminal, obpyriform or broadly ellipsoidal with a terminal exit papilla occupying the same position as that of a normal host sporangium; wall of parasite indistinguishable from that of host. Zoöspores kidney-shaped, arched, oval or ellipsoidal, containing several minute granules. Resting spores spherical, spiny, golden-brown or reddish in color; contents coarsely granular; germination unknown.

Parasitic in the horny and smooth sporangia of *Ariospora spinosa* in France (Cornu, l.c.) and Germany (Minden, l.c.) causing slight hypertrophy.

ROZELLA APODYAE Cornu, l.c. p. 161. *pl. 5, fig. 10-14.*

*R. Apodyae brachynematis* Cornu, l.c.

*Pleolpidium Apodyae* (Cornu) Fischer, l.c. p. 45.

Sporangia terminal, obpyriform, oval and ellipsoidal with an apical exit papillae; wall of parasite indistinguishable from that of host. Zoöspores apparently of the same size, shape, structure and behavior as those of the previous species. Resting spores spherical, spiny, golden-brown or reddish in color; contents coarsely granular and vacuolate; germination unknown.

Parasitic in the terminal sporangia of *Apodya brachynema* in France, causing slight hypertrophy.

As is obvious from the above diagnosis, this species is identical with *R. Rhipidii* except for slightly longer spines on the resting spores, according to Cornu, but it does not attack the latter's host, *Ariospora spinosa*, even when both hosts are growing together. It may possibly be only a physiological variety of *R. Rhipidii*.

ROZELLA IRREGULARIS (Butler) Sparrow, Mycologia 30: 377. 1938.

*P. irregulare* Butler, Mem. Dept. Agr. India 1<sup>5</sup>: 123. pl. 8, fig. 1-12. 1907.

Sporangia terminal and intercalary, spherical and irregular in shape, averaging  $23\ \mu$  in diam., with one exit papilla. Zoospores elongately obclavate with a bright globule. Resting spores lying free in hypertrophied portion of host hypha, spherical,  $11-15\ \mu$ , brown, smooth to spiny; germination unknown.

Parasitic in and causing marked local hypertrophy of the hyphae of *Pythium vexans* in England (Butler, l.c.) and *P. monospermum* in Japan (Tokunaga, 1933).

According to Butler, the presence of the parasite may lead to the formation of cross walls in the hyphae and induce abnormal branching of the hypertrophied portions.

ROZELLA CUCULUS (Butler) Sparrow, l.c.

*Chytridium simulans* Dangeard, Le Bot. 5: 21. fig. 1A-1Q. 1896. (Not *Chytridium simulans* de Bary and Woronin, 1865. p. 262.)

*Pleolpidium cuculus* Butler, l.c., p. 124. pl. 7, fig. 22-25.

Sporangia terminal in sporangia of the host, from which they can scarcely be distinguished, or intercalary in the mycelium, spherical, ovoid, or pyriform,  $19.2-24\ \mu$ , with one exit papilla. Zoospores elongately obclavate or ovoid with one refractive globule. Resting spores rare, solitary and free, spherical,  $12-18\ \mu$ , smooth, brown to pale-yellow in color; contents granular, including a large central refractive globule; germination unknown.

Parasitic in *Pythium* sp. and *P. intermedium* in France and England (Dangeard and Butler, l.c.) and *P. monospermum* in Japan (Tokunaga, 1933) causing hypertrophy of the hosts.

Whether or not Dangeard's fungus is identical with Butler's species, is, of course, uncertain, because the former worker described only sporangia and zoöspores. Butler reported only terminal sporangia, but Dangeard and Tokunaga found intercalary ones as well. Sparrow believed that *R. cuculus* probably includes *P. tuberculorum* Vuill. also.

ROZELLA BLASTOCLADIAE (Minden) Sparrow, l.c.

*Rozella* sp. Thaxter, Bot. Gaz. 21: 50. 1896.

*Plecolpidium* sp. Petersen, Ann. Myc. 8: 555. fig. XXVI c-d. 1910.

*P. Blastocladiæ* Minden, l.c., p. 253. Falck's Mykol. Untersuch. Ber. 1: 253. pl. 4, fig. 33. 1923.

Sporangia terminal, of the same shape but smaller than normal sporangia of the host, with an apical exit papilla; collapsing when empty. Zoöspores unknown. Resting spores almost spherical, brown, spiny, contents granular; germination unknown.

Parasitic in the sporangia of *Blastocladia Pringsheimii* in Maine, U. S. A., Denmark, and Germany without causing apparent hypertrophy.

This species was first observed by Thaxter in America, but because of the scantiness of material, he merely designated it as a *Rozella* parasite. Petersen referred it to the genus *Plecolpidium* but thought that it might be a species of *Olpidium*. Minden's observations and description were likewise very limited as to many of the critical developmental stages.

ROZELLA POLYPHAGI Sparrow, l.c.

*Plecolpidium Polyphagi* Sparrow, Trans. Brit. Mycol. Soc. 18: 215. 1933.

*Plecolpidium (Rozella) Polyphagi* Sparrow, Jour. Linn. Soc. 50: 426. pl. 14, fig. 19, 20. 1936.

Sporangia spherical, 20–48  $\mu$ , with 2 to 6 prominent exit papillae, 4 to 8  $\mu$  in diameter. Zoöspores narrowly ovoid, 2–3  $\mu \times$  1.5–2  $\mu$ , with one refractive globule. Resting spores unknown.

Parasitic in *Polyphagus Euglenae*, Cambridge, England, causing marked hypertrophy of the prosporangia.



ROZELLA MARINA Sparrow, *Mycologia* 30: 377. 1938.

*Pleolpidium* (*Rozella*) *marinum* Sparrow, *Biol. Bull.* 70: 256. fig. 32, 33. 1936.

Sporangia spherical, 30–45  $\mu$ , with 1 to 3 exit papillae. Zoöspores ellipsoidal,  $3 \times 2 \mu$ , aguttulate. Resting spores unknown.

Parasitic in *Chytridium Polysiphoniae*, Woods Hole, Mass., causing hypertrophy of the sporangia.

ROZELLA CLADOCHYTRII Karling, *Torreyia* 41: 105. 1941. *Am. Jour. Bot.* 29: 25. 1942.

Sporangia solitary in a host cell, spherical, 10–40  $\mu$ , ovoid, ellipsoid, 10–15  $\mu \times 15$ –35  $\mu$ , pyriform, and obclavate, hyaline and smooth with one to three exit papillae; wall of sporangium usually indistinguishable from that of host cell. Zoöspores obclavate, 3.3–5  $\mu \times 1.8$ –2  $\mu$ , aguttulate; rarely bi- and multiflagellate as the result of unequal cleavage; flagellum 14  $\mu$  long; emerging fully formed in a stream from the exit papillae and becoming actively motile in a few seconds. Resting spores faintly yellow, oval, spherical, 8–22  $\mu$ , with a large central vacuole and coarsely granular cytoplasm; wall 1–1.8  $\mu$  thick, smooth or spiny, spines 1.5–3  $\mu$  long; transformed directly into a zoösporangium in germination and forming zoöspores.

Parasitic in *Nowakowskiella profusum*, *N. elegans*, *N. ramosum*, *Cladochytrium replicatum*, *C. crassum*, and *C. hyalinum*, Bastrop, Texas, causing slight to marked hypertrophy.

Attempts by the author (1941, 1942) to infect *Endochytrium operculatum*, *Rhizophlyctis Petersenii*, *Rhizophidium globosum*, *Olpidium gregarum*, *Catenochytridium carolineanum*, *Diplophlyctis intestina*, *Entophlyctis heliomorpha*, *E. texana*, *Saprolegnia* sp., *Achlya* sp., and *Pythium de Baryanum* with this parasite have failed.

ROZELLA ENDOCHYTRII Karling, *Torreyia* 41: 106. 1941. *Am. Jour. Bot.* 29: 31. 1942.

Sporangia solitary in a host cell, spherical, 15–200  $\mu$ , oval, elongate, pyriform and irregular, depending on the size and shape of the host cell; wall of sporangium usually indistinguishable from that of the host, hyaline and smooth with one to several exit papillae, 2–6  $\mu$  high. Zoöspores obclavate, 3.4–4  $\mu \times 1.5 \mu$ , aguttulate

but with optically denser apical and basal regions which give them a characteristic appearance; swirling in the sporangium before dehiscence; emerging in a stream and becoming actively motile in a few seconds. Resting spores unknown.

Parasitic but not causing apparent hypertrophy in sporangia of *Endochytrium operculatum*, Austin, Texas.

This species appears to be restricted to one host, because extensive attempts to infect the fungi used in the study of *R. Cladochytrii* have failed.

ROZELLA RHIZOPHLYCTII Karling, Am. Jour. Bot. 29: 32. 1942.

Sporangia solitary, filling the sporangia of the host and conforming to their size and shape, spherical, 20–110  $\mu$ , oval, and irregular with 1 to 4 exit papillae which usually project out of the short necks of the host; wall of sporangium usually indistinguishable from that of host cell. Zoospores hyaline, broadly pyriform, 2.5–3  $\mu \times$  1.5–2  $\mu$ , with a slightly tapering anterior end and a minute dense body in the cytoplasm; occasionally bi- and multiflagellate; flagellum 16–18  $\mu$  long; swirling in the sporangium before emerging; darting about in swimming, rarely becoming amoeboid. Resting spores faintly yellow, oval and spherical, 14–18  $\mu$  in diameter, with a large central vacuole and coarsely granular protoplasm; wall spiny, 1.8  $\mu$  thick, spines 1.5–2  $\mu$  long; apparently transformed directly into a zoosporangium in germination and forming zoospores.

Parasitic in *Rhizophlyctis Petersenii*, Austin, Texas, without causing apparent hypertrophy or septation of the host cells.

This species also appears to be limited to one host, since all efforts to transfer it to the chytridiaceous and oomycetous fungi used in the study of the two previous species have failed. It may possibly be identical with *Rozella* sp., described by Ward (1939) in *Rhizophlyctis rosea*.

### ***Rozella laevis* sp. nov.**

Sporangia solitary, partly or completely filling hypertrophied portions of the host hyphae, variable in size and shape, spherical, 20–52  $\mu$ , clavate, 10–20  $\mu \times$  30–112  $\mu$ , broadly and elongately pyriform with 1 to 3 exit papillae, 3–4  $\mu$  in diam. by 2–3  $\mu$  in height. Zoospores hyaline, with a globular spot which is not markedly refractive, obclavate to pyriform, 1.5–1.8  $\mu \times$  2.9–3.3  $\mu$ ; occasionally

bi- and multiflagellate, flagellum 10–12  $\mu$  long. Resting spores spherical, 11–18  $\mu$ , oval, elongate or obpyriform with a large central vacuole and coarsely granular cytoplasm; wall smooth and hyaline, 1.5–2  $\mu$  thick; germination unknown.

Parasitic in *Pythium gracile*, New Kent County, Virginia, U. S. A., causing marked hypertrophy.

This species appears to be closely related to *R. cuculus*, but whether or not they are identical is uncertain. The resting spores of both species are similar in size and smooth-walled, but differ in color. The swellings caused by *R. laevis* are larger and may become divided by a thick cross or tangential wall, but no segmentation of the thallus occurs during the process of cell division. Unfortunately no cross inoculations were made with this species to determine its host range.

**Rozella Barrettii** sp. nov.

*Pleolpidium* sp., Barrett, Phytopath. 24: 1138. 1934.

Sporangia terminal and intercalary, of the same size as and indistinguishable from the host sporangia until zoöspores are formed; opening by one or more exit papillae which project through the host wall. Zoöspores numerous and minute. Resting spores unknown.

Parasitic in *Phytophthora cactorum* in California, U. S. A., causing local spherical swellings in the host hyphae as well as completely filling the sporangia.

This species is incompletely known and has been reported only in a preliminary manner. Barrett did not measure the size of the zoöspores nor describe the number, length, and position of the flagella, and until more is known about the zoöspores and resting spores, its identity and relation to other species of *Rozella* remain doubtful. Its occurrence on *Phytophthora* suggests that it may possibly be related to Miss Waterhouse's parasite and belong in *Rozellopsis*.

In connection with this synopsis of the monosporangiate species, it may be noted that Schultz-Danzig (1923) recorded an unidentified *Rozella* (*Pleolpidium*) species in *Mougeotia* sp. His description, however, is very meager, and it is not certain that the parasite belongs in this genus. If so, it is the first record of *Rozella* in

algal hosts. Sparrow (1936) has expressed the opinion that the parasite which he described as *Pseudolpidium Pythii* may also be a species of *Rozella*.

#### SEPTIGENOUS POLYSPORANGIATE SPECIES

ROZELLA SEPTIGENA Cornu, l.c., p. 163. *pl.* 6.

Sporangia in a linear row, up to 25 in delimited segments of the host hyphae, of the same size and shape as the hyphal segments, barrel-shaped, cylindrical, or ellipsoidal, with 1 to 2 apical or lateral exit papillae. Zoöspores hyaline with a small darker area or spot near the base, elongately clavate,  $1.5-2\ \mu \times 3-4\ \mu$ , arched, and oval, occasionally large and biflagellate; flagellum  $12-14\ \mu$  long. Resting spores usually solitary in segments of the main axis or the short swollen side branches or "false oögonia," spherical,  $14-20\ \mu$ , brown, spiny, spines  $2\ \mu$  long; contents coarsely granular, including a large refractive globule; producing zoöspores directly in germination.

Parasitic in *Saprolegnia* species in Germany (Nägeli, 1846; Minden, l.c.); *Achlya racemosa*, *A. polyandra*, *Saprolegnia* sp., and *S. spiralis* in France (Cornu, l.c.; Dangeard, 1890); *A. polyandra* in Russia (Sorokin, 1883, 1889); *Saprolegnia* sp., in Roumania (Constantineau, 1901); *Achlya* sp. and *Saprolegnia* sp. in New York, U. S. A., England and Czechoslovakia (Sparrow, 1932, 1936; Cejp, 1934), causing slight hypertrophy and septation of the host.

This species was apparently first observed by Nägeli who regarded its sporangia as a modification of the sporangia of what is now recognized as *Olpidiopsis*. The sporangia and zoöspores which Pringsheim (1860) described in *Achlya dioica* and which were subsequently believed to relate to *R. septigena* have recently been shown by Couch (1939) to be those of another fungus, *Pringsheimella dioica*. Whether or not the species described by Fischer (1882) as *R. septigena* is identical with Cornu's species and belongs here is obviously open to question. Fischer reported that his fungus is limited in host range to species of *Saprolegnia* and has biflagellate, heterocont,  $4\ \mu \times 6-8\ \mu$ , zoöspores which are approximately twice the size of those figured by Cornu. The latter worker also found a few large posteriorly biflagellate zoö-

spores in *R. septigena*, but he regarded them as abnormal. Cornu's observations were subsequently confirmed by Sorokin. As the author has pointed out previously (1942), Fischer may have attached too much significance to these large biflagellate zoöspores and regarded them as typical of Cornu's *R. septigena*, or he actually had another fungus in his cultures. Most mycologists have doubted the latter possibility, but it takes on greater significance in light of Tokunaga's discovery of large, biflagellate, heterocont zoöspores in a similar species, *R. simulans*, which is reported to occur only on *Achlya*. I am accordingly excluding Fischer's *R. septigena* from consideration here and transferring it provisionally with *R. simulans* to the genus *Rozellopsis*.

Cornu's observations on the zoöspores of *R. septigena* are confirmed by my observations on an *Achlya*-inhabiting, septigenous *Rozella* species with obclavate,  $1.8\text{--}2\ \mu \times 3\text{--}4\ \mu$ , posteriorly uniflagellate zoöspores and spherical,  $14\text{--}20\ \mu$ , brown, spiny resting spores. The latter germinated within two weeks and produced similar zoöspores in the manner described for *R. Allomyces* and *R. Cladochytrii*. These observations further confirm the reports of Cornu and subsequent workers on the existence of a posteriorly uniflagellate septigenous parasite in species of *Achlya*.

ROZELLA ALLOMYCIS Foust, Jour. Elisha Mitchell Sci. Soc. 53: 198. pl. 22, 23. 1937.

Sporangia terminal in host hyphae, separated by the formation of cross and tangential walls by the host and maturing in basipetal sequence, usually 1 to 5 in a row, barrel-shaped,  $12\text{--}20 \times 20\text{--}40\ \mu$ , usually with one exit papilla,  $1.3\ \mu$  high. Zoöspores ovoid,  $3\text{--}4\ \mu$  in diam., tapering at the anterior end and containing one refractive globule; flagellum about four times the length of the spore body. Resting spores formed later than the sporangia and below them in swollen segments of the host hyphae, 1 to 16 in a segment, spherical,  $12\text{--}20\ \mu$ , yellowish- to reddish-brown in color with a  $0.5\ \mu$  thick spiny wall, spines  $1.3\ \mu$  long; contents coarsely granular, including a large central globule of hyaline material; producing zoöspores directly in germination.

Parasitic in *Allomyces arbuscula*, Chapel Hill, North Carolina, causing hypertrophy and septation of the hyphae.

This species appears to be very similar to *R. septigena* Cornu, but whether or not it will infect the latter's hosts is not known. Unfortunately, Foust did not make extensive inoculation experiments with other species of water moulds.

ROZELLOPSIS Karling, Am. Jour. Bot. 29: 33. 1942.

Thallus intramatrical, holocarpic, more or less indistinguishable from but apparently immiscible with the host protoplasm; becoming invested with a wall at maturity and forming one sporangium, or cleaving (?) into several segments which become separated by host walls, mature in basipetal succession, and develop into sporangia or resting spores. Sporangia terminal or intercalary, variable in size and shape, with one to several exit papillae which extend through the host wall; usually filling the host sporangia or the hypertrophied portions of the hyphae completely; sporangium wall tightly pressed against, seemingly fused with, and usually indistinguishable from that of the host. Zoöspores slightly variable in size and shape, with one to several minute globules, biflagellate and heterocont, shorter flagellum usually extending forward and the longer one backward in swimming; zoöspores swirling in the sporangium before emerging fully formed and swimming away; contents flowing into host cell through an infection tube in germination, leaving the empty zoöspore case on the outside. Resting spores unknown in monosporangiate species; solitary in septigenous species, lying free within host cell and separate from host wall, variable in size, brown, and spiny; protoplasm coarsely granular, including a large vacuole or globule of hyaline material; germination unknown.

#### NONSEPTIGENOUS MONOSPORANGIATE SPECIES

ROZELLOPSIS INFLATA (Butler) Karling, l.c.

*Pleolpidium inflatum* Butler, l.c., pp. 126, 127. pl. 7, fig. 17-21.

Sporangia terminal, spherical, up to 85  $\mu$  in diam., oval, or pyriform with one to several exit papillae. Zoöspores reniform, kidney-shaped with the short flagellum attached at the anterior end and the longer one at the sides; swimming smoothly in long curves. Resting spores unknown.

Parasitic in *Pythium intermedium*, Antibes, France, causing marked hypertrophy of the host sporangia.

## ROZELLOPSIS WATERHOUSEII Karling, l.c.

Sporangia terminal, spherical, up to  $74\ \mu$  in diam., clavate, oval, or obpyriform with 1–3 apical or lateral exit papillae. Zoöspores pyriform,  $5\text{--}8\ \mu$  long with a few small refringent granules in the center or near the posterior end; flagella apparently laterally inserted (?); zoöspores active for 24 hours or more, or rounding up and encysting.

Parasitic in *Phytophthora cryptogea* and *P. megasperma*, London, England, causing occasional hypertrophy of the host sporangia and supporting hyphae.

Miss Waterhouse discovered this parasite in material collected from the Hogsmill River, a Surrey tributary of the Thames, and has given an excellent account of its development and infection of the host. She succeeded in inoculating *P. megasperma* with it, but all attempts to infect *Rhipidium continuum* and *R. americanum* were unsuccessful. This species differs from *C. inflatum* by its pyriform zoöspores and the fact that it causes only slight hypertrophy of the host. Because of its similarity in other respects to Butler's species, Miss Waterhouse, however, would not diagnose it as a new species. I have accordingly named it in her honor.

## SEPTIGENOUS POLYSPORANGIATE SPECIES

## ROZELLOPSIS SEPTIGENA (Fischer) Karling, l.c.

*Rozella septigena* Fischer, Jahrb. Wiss. Bot. 13: 321. pl. 14, fig. 19; pl. 15. 1882. (Not *R. septigena* Cornu, 1872.)

Sporangia up to 20 in a linear row in delimited segments of the host hyphae, of the same size and shape as the hyphal segments, with 1–2 apical or lateral exit papillae. Zoöspores elongately pyriform,  $4\ \mu \times 6\text{--}8\ \mu$ , hyaline, with a minute central refractive spot, biflagellate and heterocont; short flagellum anteriorly attached, long flagellum lateral. Resting spores solitary in segments of the hyphae or in short swollen side branches or "false oögonia," spherical,  $20\ \mu$ , with a hyaline endospore and spiny brown exospore, spines  $2\ \mu$  long, contents coarsely granular, including a large refractive globule; germination unknown.

Parasitic in *Saprolegnia monoica* and *S. Thureti* in Germany (Fischer, l.c.; Minden, l.c.), causing slight hypertrophy and septation of the host hyphae.

Fischer's attempts to inoculate *Achlya* with this species failed, and he accordingly concluded that it is limited in host range to *Saprolegnia*. His results have never been confirmed experimentally. For further discussion of this species, see *Rozella septigena* Cornu.

ROZELLOPSIS SIMULANS (Fischer) Karling, l.c.

*Rozella simulans* Fischer, l.c., p. 321; Minden, l.c., p. 271, fig. 11a; Tokunaga, Trans. Sapporo Nat. Hist. Soc. 13: 25. pl. 2, fig. 12-14. 1933.

Sporangia up to 15 in a linear row in delimited segments of the host hyphae, cylindrical, barrel-shaped,  $25-90\ \mu \times 60-250\ \mu$ , with 1-2 apical or lateral exit papillae. Zoöspores elongate, ellipsoidal,  $2.4\ \mu \times 6\ \mu$ , hyaline with a small refractive spot and two unequal flagella at the anterior end. Resting spores solitary in short swollen side branches or "false oögonia," of the same size, shape, content, and appearance as those of the previous species; germination unknown.

Parasitic in *Achlya polyandra* and *A. racemosa* in Germany (Fischer, l.c., Minden, l.c.), *Achlya* sp. in Switzerland (Mauricio, 1895), and *A. flagellata* in Japan (Tokunaga, l.c.), causing slight hypertrophy and septation of the host hyphae.

According to Fischer, this species is similar to *R. septigena* and differs only by its limitation in host range. Subsequent workers who reported its occurrence, however, did not make cross inoculations but accepted Fischer's observations without question. Inasmuch as Minden apparently did not determine the number, relative lengths, and position of the flagella of his fungus, it is just as probable that the resting spores which he figured related to *R. septigena* as to the present species. Likewise, it is not certain that Tokunaga's species is *R. simulans*, although the host reactions and sporangia are similar. He figured the zoöspores as anteriorly biflagellate and narrow, while Fischer described them as large and exactly similar to those of *R. septigena* with the short flagellum anteriorly attached and the long one lateral. Consideration, however, must be given to the difficulty of determining the exact position of the flagella on active zoöspores, and it is possible that these differences in observations are due to this factor. If this species



is identical to *R. septigena*, as Fischer maintained, and will infect only *Achlya*, it may probably be a physiological variety of the former species.

## SUMMARY

*Rozella* is interpreted in the original sense of Cornu and includes thus only species with posteriorly uniflagellate zoöspores. *Pleolpidium* Fischer accordingly becomes a synonym of this genus. In its present status *Rozella* includes thirteen nonseptigenous monosporangiate species and two septigenous, polysporangiate species. *Rozellopsis* has been created for all known *Rozella*-like species with biflagellate heterocont zoöspores. It includes at present two imperfectly known nonseptigenous monosporangiate members and two questionable septigenous polysporangiate species.

BOTANY DEPARTMENT,  
COLUMBIA UNIVERSITY,  
NEW YORK, N. Y.

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# SEXUALITY IN ALLOMYCES CYSTOGENUS

JAMES McCranie

(WITH 1 FIGURE)

The genus *Allomyces* has been subdivided by Emerson (1941) into three subgenera on the basis of the type of life cycle. Those forms in which there is an alternation of an asexual plant, bearing zoösporangia and resistant sporangia, with a sexual one, bearing paired male and female gametangia, are included in the subgenus *Euallomyces*. Some isolates have repeatedly failed to produce a sexual generation. The single type of thallus in these forms corresponds in its general morphology to the asexual plant of members of the subgenus *Euallomyces*, i.e., bearing zoösporangia and resistant sporangia. Such forms are segregated into a subgenus, *Brachyallomyces*. The third subgenus, *Cystogenes*, likewise, has only one generation. Its thallus is similar to that of *Brachyallomyces* and to the asexual plant of *Euallomyces*. Here, however, according to Emerson, the zoöspores released upon the germination of the resistant sporangia are biflagellate instead of uniflagellate as in *Euallomyces* and *Brachyallomyces* and, instead of developing directly into thalli, they encyst and later give rise to a tetrad of uniflagellate zoöspores each of which then develops into an asexual thallus.

In the absence of cytological evidence it is not possible to interpret with certainty the *Cystogenes* life history. Emerson points out the close similarity between the biflagellate primary R.S. zoöspores (zoöspores from the germinating resistant sporangia) and the biflagellate planozygotes of *Euallomyces* and, in an attempt to explain this similarity, suggests that sexual fusions may take place inside the resistant sporangia during their germination. In other words, the primary R.S. zoöspores might actually be zygotes. The production of secondary R.S. zoöspores (zoöspores produced in the cysts) in groups of four indicates that meiotic divisions may

occur in the formation of these spores in the cysts. If these suggestions are correct, the thallus of *Cystogenes* is haploid.

It became clear to the writer while working on the cytology of the genus that this inference is improbable for reasons which will be presented when the cytological results are published. But aside from cytological evidence, the improbability of such an interpretation was realized from morphological observations. In the first place, the writer has never found the primary biflagellate R.S. zoöspores reported by Emerson as coming directly from the resistant sporangia. In studying the germination of the resistant sporangia of *Allomyces cystogenus*<sup>1</sup>: (Emerson's Burma 1B isolate) the immediate product of germination has always been non-flagellate spores which encyst in a group immediately after discharge. This absence of biflagellate primary R.S. zoöspores eliminates the reason for supposing that sexual fusions might occur in the germinating resistant sporangia. In the second place, the cysts produced by the non-flagellate spores are quite variable in size and produce from one to several zoöspores. This fact, that only one secondary R.S. zoöspore may be formed in certain of the smaller cysts, decreases the probability that a meiotic division occurs in the formation of the secondary R.S. zoöspores. In the third place, the obvious difference in size between secondary R.S. zoöspores of *A. cystogenus* and the zoöspores from its zoösporangia early led the writer to doubt the correctness of Emerson's suggestions. If the thallus were haploid, both these types of zoöspores would necessarily be haploid. But if the two types of zoöspores contain the same chromosome number, it seems quite anomalous that the zoöspores from the zoösporangia are typically twice as large as the secondary R.S. zoöspores.

As a result of these observations, a study of the behavior of the secondary R.S. zoöspores was made. In this study resistant sporangia that had been separated from the thallus and thus freed of any other possible gamete-producing structure were germinated in water on a slide under a supported cover slip and watched under the microscope. The resistant sporangia of this strain of *A. cysto-*

<sup>1</sup> The writer is indebted to Dr. Emerson for his kindness in supplying this fungus and others.

*genus* germinate quite readily after they have been allowed to reach full maturity. Since they are partially deciduous, large numbers of the resistant sporangia may be collected on a cover slip placed underneath a mass of thalli. They may also be separated by allowing the complete desiccation of the thalli and zoösporangia.

Fully mature resistant sporangia usually begin to germinate in a short time after being placed in fresh water. The outer, thick wall

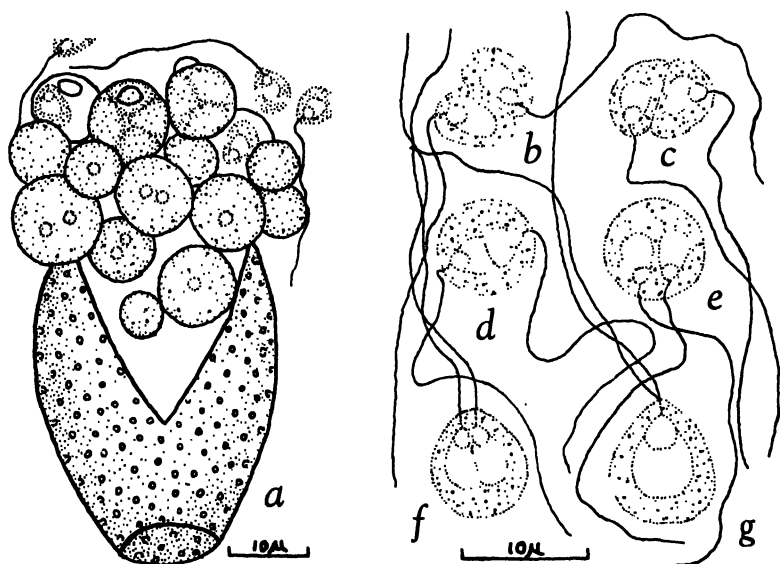


FIG. 1. *a*, germinated resistant sporangia of *Allomyces cystogenus* showing spores in the encysted stage at the point of discharge and isogametes from the germinating cysts; *b* and *c*, semi-amoeboid gametes just before fusion; *d*, *e* and *f*, stages in the orientation and fusion of the nuclear caps; *g*, biflagellate zygote.

cracks open irregularly and the sporangial content almost doubles in volume. The protoplasm cleaves into blocks of varying size, most of which contain more than one nucleus. These cleavage products are discharged from the sporangium through dehiscence papillae. In the writer's observations these structures have never been found to be flagellate. They usually encyst in a group at the point of discharge (FIG. 1, *a*). Immediately, or after a quite variable period, they proceed to the production of the secondary swimmers.

Careful observation of these isogamous swarmers produced in the cysts resulted in the noting of their actual copulation. In the process, semi-amoeboïd gametes, heretofore referred to as secondary R.S. zoöspores or swarmers, come together in pairs and crawl over each other with amoeboïd movements (FIG. 1, *b* and *c*) immediately after discharge from the cysts or after a preliminary swarming period. In a few minutes after contact, sometimes only a few seconds, it is apparent that the amoeboïd movements have become those of only one individual rather than two. Shortly after this becomes apparent, the amoeboïd movements cease altogether and the zygote jerks itself into a compact form (FIG. 1, *g*) and swims away by means of its two flagella. (Figure 1, *d*, *e*, and *f* show stages in the fusion of the nuclear caps.) In general morphology and size these biflagellate zygotes are identical with the uniflagellate zoöspores produced in the zoösporangia. Furthermore, both germinate into the same type of thallus—the typical *Cystogenes* plant. Since the zygote is necessarily diploid, it is obvious that the *Cystogenes* thallus is, likewise, diploid. It is possible that this fusion may occur in some strains and not in others, inasmuch as my observations are still limited to this one strain.

Although the copulation of isogametes has previously been reported in the Blastocladiaceae, in *Blastocladiella* by Harder and Sorgel (1938) and in *Sphaerocladia* by Stüben (1939), this is the first description of this type of sexuality in the more highly developed genus *Allomyces*. To heterogamy, established in the genus by Kniep (1929) in *Allomyces javanicus* and confirmed by Hatch (1933) in *A. arbusculus*, is thus added isogamy.

At first thought it might be concluded that *Allomyces cystogenus* with its isogamous sexuality is a connecting link between isogamous *Blastocladiella* and *Sphaerocladia* and heterogamous *Allomyces javanicus* and *A. arbusculus*. All four of the latter, however, have alternation of generations in which the sexual and asexual plants are equally conspicuous. But there is not such an alternation in *A. cystogenus*, the gamete-producing structures being merely cysts. It seems more likely, therefore, that this fungus is merely a "brachy-" form derived from a *Euellomyces* type in which the gametophyte generation has been reduced to a cyst.

In conclusion, the writer expresses his appreciation of the guidance of Dr. L. E. Wehmeyer and Dr. F. K. Sparrow in the present study.

SOUTH GEORGIA COLLEGE  
DOUGLAS, GEORGIA

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## NOTES AND BRIEF ARTICLES

"Myriangiales Selecti Exsiccati," Fascicle 1.<sup>1</sup>—In the contribution, "Myriangiales Selecti Exsiccati," presented at the Primeira Reunião Sul-Americana de Botanica held in Rio de Janeiro in October 1938, the authors, Anna E. Jenkins, U. S. Department of Agriculture, Washington, D. C.; and A. A. Bitancourt, Instituto Biologico de São Paulo, Brazil, announce a new series of exsiccati so entitled.<sup>2</sup> Fascicle 1, prepared in connection with the meeting, has now been issued from São Paulo under the date of December 1940. It is based upon the article by the same authors entitled "Ilustrações das doenças causadas por *Elsinoë* e *Sphaceloma* conhecida na America do Sul até Janeiro de 1936." (Arqu. Ind. Biol. São Paulo 10: 31–60, 1939), and a copy of this publication accompanies each fascicle. Following the plan for the series, the fascicle contains fifty specimens and is issued in 10 sets. The fifty specimens are enumerated in the announcement of this special new set of exsiccati.

All but two of the fourteen species treated in the above-mentioned article of 1936 are represented in the fascicle. The two species lacking are *Elsinoë amazonica* and *E. calopogonii*, of which no specimens for distribution are available. Type collection material is included of *E. australis*, *E. randii*, *Sphaceloma genipae* and *S. terminaliae*, as well as material of *E. fawcettii* from the type locality. The other seven species in the fascicle are *E. ampelina*, *E. piri*, *E. veneta*, *S. mattirolianum*, *S. perseae*, *S. populi*, and *S. rosarum*.

With the exception of two specimens bearing the date 1925, all of the material in Fascicle 1 was gathered during the 10-year period 1931–40. The collectors are chiefly present day workers in mycology and plant pathology in South America, as well as in several cases those from the United States who have been sta-

<sup>1</sup> This note was prepared by the authors of this set of exsiccati.

<sup>2</sup> The article referred to is in press in volume 4 of the Annals of this meeting.

tioned in South America for a time. Among the specimens gathered especially for the fascicle are those of the little known species, *Sphaceloma populi*, from the same parts of Argentina and Chile where this fungus was discovered in these countries by Spegazzini, in 1880 and 1909, respectively. As previously explained, this species was originally described from Italy, in 1878, as *Hadrotrichum? populi* Sacc.

One set of Fascicle 1 has been deposited in the Farlow Cryptogamic Herbarium, Harvard University, Cambridge, Massachusetts, and another in the New York Botanical Garden, New York, New York, U. S. A., while one set has been reserved for the Instituto Biologico, São Paulo, Brazil, and one for the U. S. Department of Agriculture, Washington, D. C. The remaining sets are held in reserve for similar deposit in other representative mycological herbaria when world conditions permit.

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### Announcement

Since the publication of the first edition of *The North American Cup-fungi (operculates)*, in 1928, there has been a steady demand for this work. All of the bound copies were disposed of some time ago and, much new material having accumulated since that time, it seemed best to the writer to issue the remaining unbound copies in a supplemented form. The new edition contains all the material in the first with nearly 100 additional pages of text and 28 additional plates, four of which are in color.

Since the Supplemented Edition is very limited in number, only about half those of the first, it is expected that the edition will be disposed of rather readily. For the benefit of those who do not wish to purchase the combined form, paper bound copies of the supplement alone are available. This book is privately published and for further details address the author.—FRED J. SEAVER.

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### A NOTE ON NOMENCLATURE

The evidence submitted by Dr. Rogers<sup>1</sup> indicates that S. F. Gray's *Natural Arrangement of British Plants* appeared later in

<sup>1</sup> *Mycologia* 33: 568. 1941.



1821 than Volume I of Fries's *Systema*, and raises several interesting points. Under the present Rules, about forty generic and 230 specific names of Hymenomycetes may now be considered to have been first validly published in Gray's book.

As regards the Agaricaceae, the authorities for older generic and specific names are now being cited in various ways, as one author tries to follow the International Rules literally and another considers that the sub-genera of Fries are to be treated as, in effect, genera. The latter view was proposed for legalization by C. W. Dodge,<sup>2</sup> considered and rejected by the mycological section on nomenclature in 1935, then turned over to a committee, but has not yet come before the whole Congress. One may, therefore, still follow the latter practice until Congress makes a decision.

Those who interpret the Rules literally now have a new source-book and can cite, for example, *Amanita* (Fries) S. F. Gray, 1821 (or *Amanita* (Pers. ex Fries) S. F. Gray) with some assurance; Secretan (1833), Fries (1836 or 1838), Quélet (1872), and others have been presumed to be the first after the *Systema* to raise *Amanita* to generic rank. However, there are less fortunate results: to cite one example, *Crepidopus* (Nees) S. F. Gray (as well as *Resupinatus* and *Micromphale*) has priority over *Pleurotus* (Fries) Quél. But surely most of the familiar Friesian names should be conserved.

The International Rules state (Art. 4) "The essential points in nomenclature are: (1) to aim at fixity of names (2) to avoid or reject the use of forms and names which may cause error or ambiguity or throw science into confusion." Dr. Linder stressed this view in his Presidential Address.

Fries deservedly dominated mycology, although of course certain of his contemporaries excelled him in some one group or another. S. F. Gray was mainly a compiler. To validate the proposal to start the nomenclature of all "fungi caeteri" with Jan. 1, 1821, instead of 1821-32 would necessitate tiresome and futile search of the numerous publications of that period for the earliest "validation," whereas the start of each group from its publication in the *Systema* does give a definite citation at once. Many of Dr.

<sup>2</sup>Ann. Missouri Bot. Gard. 21: 1934.

Dodge's arguments (loc. cit.) in favour of recognizing Friesian subgenera apply against starting with 1821. The correct authorities for many species not described as new in *Systema* II and III would be uncertain and variable, just as those of Agaricaceae are now. Take *Botrytis cinerea*, for example: S. F. Gray apparently did not compile it (though he has *Polyactis vulgaris*); in any event his work is presumed to date from November, 1821. Not until someone found the very first publication or exsiccatus issued on or after Jan. 1, 1821, with the name *B. cinerea* Pers., could he definitely "validate" the name as "*B. cinerea* Pers. ex X, 1821."

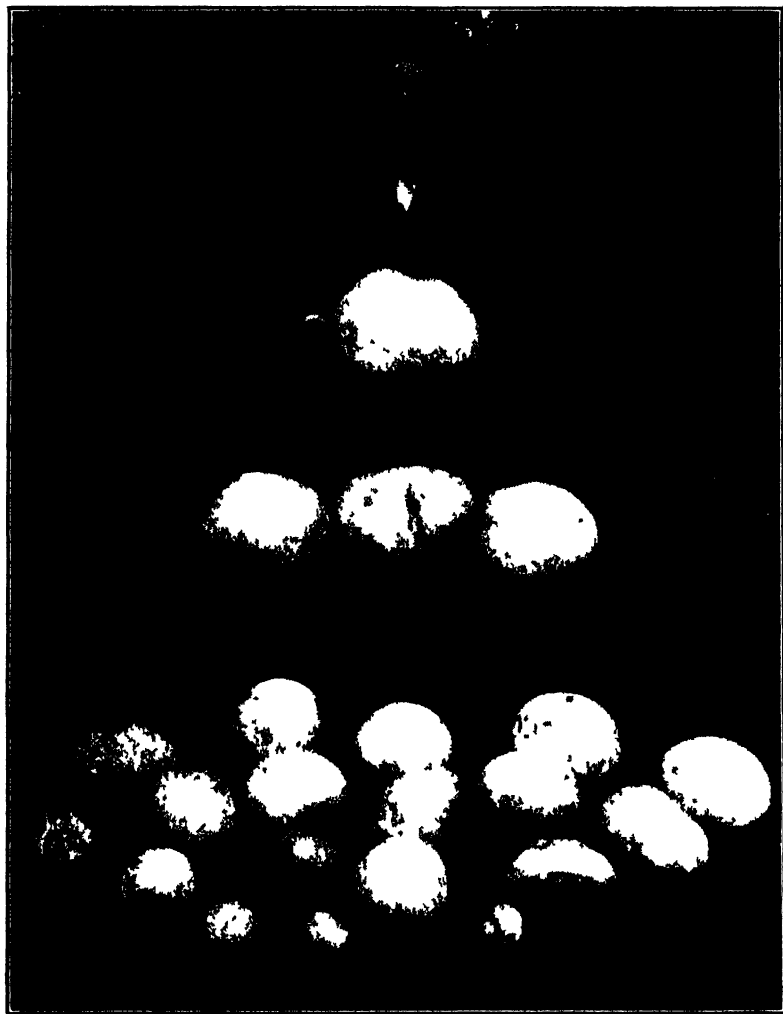
Incidentally, it seems to the writers that mycologists might well follow the example of Phanerogamic botanists and omit pre-valid author names except in formal taxonomic treatises, even though it be considered that a Persoon or a Link specimen is the type; e.g. use *Cladosporium herbarum* Fries instead of the awkward citation necessary to introduce both Persoon and Link (something like *C. herbarum* ([Pers.]) Link ex Fries). Also it should be noted that the first species an author cites under a new genus (with two or more species but no type specified) need not necessarily be chosen as lectotype.

We hope American mycologists will carry on the task of assembling and publishing data on nomina generica conservanda already proposed—some of them thirty years ago.—G. R. BISBY, E. M. MASON, AND E. M. WAKEFIELD.

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#### PUFF-BALLS IN OHIO

The "puff-balls," the so-called fruiting bodies of the species *Calvatia gigantea*, shown in the accompanying illustration were collected along the Miami River not far from Quincy, Ohio, on October 19, 1941. The occasion was a vacation outing under the guidance of cousins (Mr. and Mrs. Arthur Davis of Jackson Center, Ohio) who are both well informed on, and highly appreciative of, the wild life and the natural beauty along the Miami River. In planning the day they had remarked that it was the season when puff-balls the "size of one's head" were to be found. The photo shows that their statement of comparison might well have made reference to a much swollen head.



A collection of giant puff-balls (*Calvatia gigantea*)

These puff-balls were found along the river in three localities separated by only a few miles. One was a grassy pasture with few scattering trees, and here the smallest of the specimens were found. The locality with the six largest puff-balls was a grassy slope leading to a vale. Nearby woods and scattering trees and stumps on the area indicated that a stand of timber had been removed in recent years. Here the puff-balls were mostly clustered with two

or more close together. Two of the largest of somewhat irregular shapes, in the photograph shown at the left on the table, had their stalks only about two inches apart at the level of the soil. In their expansion they had become closely pressed together. The third locality was one of rather densely wooded and steep slopes along a narrow vale in which there were springs and a small rivulet. There was no grass and there was a thin surface layer of leaf- and wood-humus which was deepest in pockets along the uneven slopes. Here the puff-balls were scattered, mostly solitary, and more nearly spherical.

A considerable number of other puff-balls were seen but not collected. Some of these were turning brown; some were of small size. No doubt many more specimens could have been found in other localities along the river.

The largest specimen weighed 10 lbs. and two ounces when weighed a few hours after it was collected. It was carefully packed in a bushel basket and brought by auto to the New York Botanical Garden for the mycological collection. At the present time its weight has decreased to 11 ounces. Evidently a fresh puff-ball of large size contains much water.

As for the fate of the other specimens. Most of them were consumed as food. A goodly number of them were distributed among friends and some of these had their first taste of puff-ball mushrooms. The persons who made the collection had their full share. In the preparation most favored by the writer a puff-ball that is fully white inside and quite solid is sliced, the outer rind is removed, and the slices are placed in weakly salted water for about twenty minutes. Then they are drained, dipped in a mildly seasoned batter of milk, melted butter, beaten eggs, and cracker or bread crumbs, and then fried to a brown in an iron skillet. The procedure is quite like that often employed in cooking egg plant. There are persons who consider puff-balls thus prepared to be a real delicacy.—A. B. STOUT.

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#### A NOTE ON SEGREGATION TYPES IN *GLOMERELLA*

A paper which should prove of great interest to mycologists was presented by T. M. Sonneborn before the Genetics Society of

America meeting recently at Dallas. This author has investigated extensively the question of mating types in certain races of *Paramecium*. Without going into details it may be said he found, as he interprets his results, that the gene for mating type I mutates with high frequency to an allele for mating type II. Identical homozygous micronuclei give rise to diverse macronuclei which in turn determine mating types. The frequency of mutation varies from 35% to 87%, depending on the temperature within the range 10° to 35° C. This rate "is enormously greater than any hitherto recorded."

If Sonneborn's interpretations are allowable for his races of *Paramecium*, mycologists are certainly justified at least in considering again, even if not in adopting, the same reasoning to account for the interfertility of geographical races of mushrooms somewhat as suggested by Kniep, and also to explain the results obtained in their studies of *Glomerella* (Edgerton, Am. Jour. Bot. 1: 244-254, 1914; Andes, Bull. Torrey Club 68: 609-614, 1914; Lucas, Chilton & Edgerton in papers read before the Myc. Soc. Am. at Dallas). There is now agreement as to certain questions concerning *Glomerella*. A *light* or + race must very rarely sector or mutate to *dark* or — in plate cultures. If the eight spores are dissected from asci in ascocarps matured by a certain "*light*" race and are grown separately, three main types of segregation are shown to have occurred. (1) Rarely all eight spores give rise to *light* races or cultures. (2) All eight give rise to *dark* (—) races. (3) Four spores give *light*, and four give *dark* races. Occasionally there is a 2:6 break. Essentially the same types of segregation occur when one selects asci from ascocarps maturing along the dark line of meeting where a *dark* race is grown opposite a *light* one in plate culture.

Since from only three asci out of some 140 (97% +) analyzed did Andes find all eight spores gave rise to *light* races, one would certainly be justified in refusing to consider mutation from *light* to *dark* to account for the small number of asci, in which no mutation was manifested. Before discarding this idea, one should consider another possibility. The nuclear history of our *Glomerellas* has not been adequately studied. Assuming for the moment, that *Glomerella cingulata* is homothallic, a single mutation from *light*

to *dark* occurring in a nucleus of a cell of a young ascogenous hypha would, because of proliferations, provide a number of asci which would be homozygous for dark and therefore would cut out eight "*dark*" spores. Four "*light*" and four "*dark*" spores in other asci in the same or other ascocarps would result from a similar mutation occurring in one of the two haploid nuclei fusing in the ascus so that after fusion it would be heterozygous for *light* and *dark*. Likewise a mutation at meiosis in an ascus homozygous for *light* would result the same way.

What is needed now more than anything else is the discovery of more genes, some linked with, some independent of, the genes for *light* and *dark*. In this way the question of homothallism versus heterothallism and of hybridization when *light* and *dark* races are opposed could most readily be settled.

Those who are investigating *Glomerella* are provided with a fungus which may serve beautifully to explain how homothallism may arise from heterothallism or vice versa, and how the effects of mutations may simulate effects of hybridization.—B. O. DODGE.

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#### BOOK REVIEW

LEACH, J. G. *Insect Transmission of Plant Diseases*. xviii + 615 pages, 238 figures. McGraw-Hill Book Company, Inc., New York, 1940.

In the specialization of recent years adjacent fields have been investigated with such intensive concentration and such devoted single-mindedness that workers in one area often have been relatively unaware of developments in closely parallel or slightly divergent fields. As a result, when there emerges a book which synthesizes and correlates the material in related fields, interpreting and clarifying their interaction and interdependence, workers in these fields are greatly benefitted, further advances are directly stimulated, and science as a whole is markedly enriched.

Such a significant and valuable contribution is this book by Leach; in itself an outstanding contribution to Biology, and an immediate aid to plant pathologists, entomologists, and mycologists; in its influence a sure catalyst of further productive activity.

The book is adequate, able, well done. In it there is little to criticize, less to correct, naught to condemn.

The organization follows a well-thought out plan, proceeding progressively by logical steps in natural developmental sequence, its categories and subdivisions unfolding the subject matter in easily followed succession in its 17 chapters.

After the introduction has covered the historical and developmental background of the insect transmission of plant diseases, a general chapter outlines the interrelationships and interdependence of plants and insects through their close association in long evolutionary development, while chapter III discusses the intimate and more specialized relationships of symbiosis in its complex and biologically important aspects, and points out the bearing of these on plant pathology. Chapter IV, beginning the main line of the book, traces the growing appreciation of the relation of insects to the spread and development of plant diseases, from pioneer work such as that of Waite on fireblight through the rapidly increasing development that has led to the present, development in which Leach has been one of the most active contributors. Here also is discussed the part played by insects in such biologic problems as the origin of new diseases through hybridization of plant pathogens by means of insect transmission of their reproductive entities.

The six chapters which follow consider in specific detail the relation of insects to various categories of plant diseases, categories based, in my opinion very wisely, on the nature of the causal agent, rather than on the necrotic, hyperplastic, or hypoplastic reaction of the host. For each of these categories—diseases caused by toxicogenic insects, by bacteria, by fungi, by viruses, and by protozoa—there is an adequate and effective presentation of complex material hitherto dispersed, disorganized, and difficult of access. Especially commendable is the competent and thorough treatment in the 107 pages of chapters VIII and IX of the complicated relation of insects to virus diseases. Chapter XI with its discussion of mites, nematodes, and other small animals as vectors of plant diseases presents interesting parallels to the cases of insect transmission already considered and makes the reader realize that these and perhaps other living agencies should not be disregarded.

After these specific examples follow 4 chapters no less valuable, covering in about 90 pages matters important to the understanding of the field of insect transmission of disease in its wider, more general aspects. In their relation to insect transmission are discussed the anatomy and physiology of host plants and of insect vectors, the inocula of pathogens, and the feeding and breeding habits of insects. Illuminating and significant, also, is the 20-page chapter comparing the older field of the insect transmission of animal diseases, better known through work in medicine and economic entomology, with the more recently appreciated subject of insect transmission of plant diseases. A final chapter on methods of investigating the relation of insects to the spread and development of plant diseases makes available to the reader the strategy and tactics, the arms and equipment, for attacking the many problems yet unsolved.

As typographical errors, in keeping with the conscientious care manifest throughout, are signally few and will be corrected in subsequent editions, they do not detract from the text. Indeed, a few actually enliven it, "casual fungus" suggesting a lighter side to the grim activities of a pathogen, "interpendence" coining a neat word of definite potentialities, "drive nourishment from the host" suggesting hitherto unexpected blockade tactics, and "Zodiophilous" implying astrological relation to the Zodiac rather than biological relation to dissemination by animals.

Factual errors, as might be expected, are notably rare. The statement on page 28 that "all members of the Entomophthorales are exclusively parasitic on insects" is hard to reconcile with the mode of life of *Basidiobolus*, *Conidiobolus*, and *Completoaria*. That this is the only critical mistake which attracted my attention may of course be due to the fact that the Phycomycetes are the only group of fungi with which I am familiar. Others, expert in other groups, may find additional errors, but I doubt if these will be numerous.

The 238 figures, comprising half-tones and line-cuts, are well chosen and effectively support and illustrate the text. They are uniformly excellent, only figure 77 suffering from "half-tone fog," so that the "eggs of the seed corn maggot, etc.," undoubtedly ob-



vious in the original glossy print, now are lost in the general camouflage unless pointed out to the uninitiated. For some reason the legends seem to have a greater proportion of typographical errors than the text. Some of these, also, have their brighter side, the male mite in figure 179 apparently kicking with all four pairs of appendages in protest against being labelled a "non-gravid female," while "mid-intestine of the lava" startles the reader by its unexpected lapse from Entomology into Vulcanology.

Each chapter of the book is a complete entity effective in itself, with its own adequate list of pertinent references; an advantage to the student investigator who is more likely first to consult individual chapters in connection with his work and later to read the book in its entirety. As a result, there is inevitable repetition in subject matter and in supporting references, but even to those who read the book in its entirety this repetition is not disadvantageous, the encountering of matter already grasped soothing the ego and aiding in the interpretation and understanding of additional material.

The appendix, of 22 pages, is a very valuable feature as, in 6 comprehensive tables which group causal agents and vectors in parallel columns and compare representative plant diseases with respect to significant features of transmission, essential facts necessarily overlaid with abundant detail in the text are here brought out vividly with helpful clarity of perspective. It is thus a skeletal exposition of similarities and differences, an abstract of essential features, facilitating ready and instructive comparison, a convenience for reference and for teaching.

The glossary of 9 pages, covering adequately the essential terminology of plant pathology, entomology, and mycology, as involved in the book, is valuable and useful. The definitions are clear and effective, well chosen and adequate, adding much to the value of the book, leaving little to criticize. Yet the definitions of facultative parasite and saprophyte, although clear, involve an unfortunate awkwardness of expression which Dr. Leach certainly would not accept in the writings of his students. Also, although the adjective *homosexual*, as here defined to mean "producing only one kind of gamete," might innocently enough be applied to your reviewer, such a characterization would certainly arouse my resentment con-

sidering the implications of the accepted usage of Webster's Dictionary or of psycho- rather than phyto-pathology.

The glossary is especially valuable to barbarians like myself, unversed in the Whetzelian terminology, since it explains the exact sense in which terms such as dissemination, transmission, inoculation, ingression, infection, etc., are used here. Consistent adherence to this terminology, however, seems to be difficult even for the author since, despite his loyal usage of "suscept," he occasionally, as on pp. 189, 408, et al., descends to the ostracized word "host." Also the author is forced, in his discussion under "transmission," to attempt justification of "Insect Transmission of Plant Diseases" as his title, a heinous example of the "baneful influence" of mycology and of "the prevalent practice of treating the pathogene and the disease as synonymous concepts," flagrantly contrary to the Maestro's insistence that "Disease is a physiological process, or better, perhaps, an interrelated group of processes; . . . the composite of reactions of the plant to the causal factor or factors operating upon it."

An excellent working index of 20 pages, well organized, inclusive, and usable, completes the book.

The book is of two-fold value. As a comprehensive, thorough, and able presentation of hitherto unassembled material in an important field it fills a long-felt need and is most welcome. In addition, as a stimulus to further research it may well prove even more valuable to science. Throughout its pages the attitude of the investigator is revealed, for, along with his masterly assembly of what already has been accomplished, Leach points out what needs to be done, the significant questions unanswered, the interesting points still obscure, the important problems as yet unsolved. By a mere compiler the things that need to be done are often unnoticed, but to an active and inquiring investigator such as Leach, years of active work, together with the absorption of a vast amount of literature pertinent thereto, reveal innumerable problems that clamor for solution.

Furthermore, to the investigator with broad vision, the solution of such problems for the advancement of science is more important than their retention for the advancement of the individual. Hence in this book there is no jealous withholding of stimulative sugges-

tion, no hoarding of potential problems for the benefit of the writer and his students. On the contrary, the book is rich in stimulative suggestions, practically every page pointing out some important problem in need of investigation, some question of significance as yet unanswered. As a result, your reviewer predicts an increase of activity in this field. The student who, on reading a book so complete and comprehensive, is likely to consider the field closed with nothing left to do cannot possibly react in that way to this book. To the beginner, whether plant pathologist, mycologist, or entomologist, this book gives long sought stimulus, guidance, and inspiration. He may start reading with his mind in the condition of page 594, but by the time he has reached that page he will have been furnished numerous problems in his own field of interest, supplied with helpful background, methods, and references, and aroused into investigative activity.

Indeed, among advanced workers the catalytic effect of this book is certain to activate further investigation valuably contributive to the advancement of Biology.

"To the vector belong the spoils"; to the author belongs the credit for a significant and stimulative contribution.—WM. H. WESTON.

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## MYCOLOGICAL SOCIETY OF AMERICA

### REPORT ON THE 1940 FORAY

The 1940 Foray was held in the Mt. Katahdin region of Maine, August 20-24, with the collaboration of the Department of Botany and Entomology of the University of Maine. Headquarters were at Millinocket. The attending mycologists found very pleasant and convenient living quarters at the excellent Great Northern Hotel and adjacent tourist homes, a situation which made for close social relationships that resulted in one of the most enjoyable Forays in recent years. Satisfactory laboratory facilities were provided by the Millinocket School Board not very far from the living quarters. The collecting trips were organized by Dr. F. H. Steinmetz of the University of Maine. The collecting grounds, which should have been excellent, were at Norcross, the trails of

Mt. Katahdin and the environs of Millinocket. The Reverend Stanley A. Gould of Millinocket graciously acted as local host, assisting in making local arrangements and in the collecting, and in entertaining those of the party not interested in the field trips.

Thirty-seven people were in attendance, twenty mycologists and the remainder wives, children or friends.

The usual meeting which followed a dinner at the Great Northern Hotel, was presided over by the President of the Society, Dr. D. H. Linder. The usual resolutions were passed expressing the appreciation of the Society for the efforts of the following individuals or organizations: Dr. F. H. Steinmetz for his part in planning for and carrying out the Foray; the Millinocket Chamber of Commerce for assistance in arranging the Foray; the Millinocket School Board for providing excellent laboratory space at the High School; the Rev. Stanley A. Gould for contributing his time, services and geniality on all occasions. There was the usual discussion of the Foray for 1941. It was voted that the Committee on arranging this Foray should prepare a complete list of collections for publication in MYCOLOGIA.

The Mt. Katahdin area was selected for this Foray originally because of the generally expressed desire for an opportunity to collect in some part of Maine and also because this region was recommended as one where year-in and year-out moisture conditions are favorable for fungous growth. By the perversity of fate, however, it was found upon arrival that this year was the driest in 40 years, with no rain for 6 weeks. The situation was saved only by an all-day rain the day before the Foray opened. Therefore the collecting was not as good as expected.

During and just after the Foray 394 species and varieties were collected, not a bad number for the preceding bad weather conditions. The symbols in parentheses indicate the sources of the reports from which the list was compiled. Unfortunately, the collections of L. O. Overholts are not included here.

C = Victor M. Cutter, Jr., Cornell University

H = L. K. Henry, Carnegie Museum, Pittsburgh

K = F. D. Kern, Pennsylvania State College

L = D. H. Linder, Farlow Herbarium, Harvard University

M = G. W. Martin, University of Iowa

P = A. G. Plakidas, Louisiana State University

S = C. L. Shear, Washington, D. C.

Si = J. W. Sinden, Pennsylvania State College

Sn = Walter H. Snell, Brown University

St = F. H. Steinmetz, University of Maine

Ste = Neil E. Stevens, University of Illinois

T = G. S. Torrey, University of Connecticut

W = Maurice B. Walters, Cleveland, Ohio

Wh = combined collections of H. H. Whetzel and Thomas Sproston.

The Myxomycetes marked with an asterisk (\*) were developed in moist chambers by G. W. Martin.

ACRASIEAE: *Polysphondylium pallidum* Olive (M).

MYXOMYCETES: *Arcyria cinerea* (Bull.) Pers. (M, I.); *A. incarnata* Pers. (M); *A. nutans* (Bull.) Grev. (M); *Badhamia rubiginosa* (Chev.) Rost. (M); *Ceratiomyxa fruticulosa* (Mull.) Macbr. (H, M, T); *\*Comatricha elegans* (Racib.) List. (M); *\*C. pulchella* (Bab.) Rost. (M); *C. typhoides* (Bull.) Rost. (M); *Craterium minutum* (Leers) Fr. (M); *\*Cribraria microcarpa* (Schr.) Pers. (M); *C. tenella* Schrad. (M); *Diachea leucopodia* (Bull.) Rost. (M); *\*Dictydium cancellatum* (Batsch) Macbr. (M); *\*Diderma effusum* (Schw.) Morg. (M); *D. globosum* Pers. (S); *D. testaceum* (Schr.) Pers. (L, M, S); *Didymium complanatum* (Batsch) Rost. (M); *D. minus* Morg. (M); *D. squamulosum* (A. & S.) Fr. (L, M); *D. xanthopus* (Ditm.) Fr. (M); *\*Echinostelium minutum* deBy. (M); *Fuligo septica* (L.) Wigg. (M); *Hemitrichia clavata* (Pers.) Rost. (L); *H. Serpula* (Scop.) Rost. (T); *H. stipitata* (Masse) Macbr. (M); *H. Vesparium* (Batsch) Macbr. (M); *\*Lamproderma scintillans* (Berk. & Br.) Morg. (L, M); *Leocarpus fragilis* (Dicks.) Rost. (H, M, S); *\*Licea minima* Fr. (M); *Lycogala epidendrum* (L.) Fr. (M); *\*Ophiotheca chrysosperma* Currey (M); *\*Orcadella operculata* Wingate (M); *Physarum bivalve* Pers. (L); *P. cinereum* (Batsch) Pers. (M); *\*P. globuliferum* (Bull.) Pers. (M); *P. viride* (Bull.) Pers. (L, M); *Reticularia lycoperdon* Bull. (Sn); *Stemonitis flavogenita* Jahn (M); *S. fusca* Roth (M); *\*S.*

*nigrescens* Rex (M); *Trichia favoginea* (Batsch) Pers. (M); *T. persimilis* Karst. (M); *Tubifera ferruginosa* (Batsch) Gmel. (M).

PHYCOMYCETES: *Mucor plumbeus* Bon. (C); *M. racemosus* Fres. (C); *Peronospora obducens* Schroet. (L); *Sporodinia grandis* Link (C).

PYRENOMYCETES: *Amphisphaeria aethiops* (B. & C.) Sacc. (S); *Chromocrea gelatinosa* (Tode) Seaver (L); *Claviceps purpurea* (Fr.) Tul. (L); *Cordyceps acicularis* Rav. (L); *Daldinia concentrica* Bolt. ex Fr. (L, S); *Dialonectria Peziza* (Tode) Seaver (L); *Diatrype stigma* (Hoff.) Fr. (S); *Diatrypella verruciformis* (Ehr.) Nat. (S); *Erysiphe Chelonis* Schw. (= *E. Galeopsidis* DC sensu Salmon) (L); *E. lamprocarpa* (Wallr.) Duby (L); *Eutypa flavovirens* (P.) Tul. (S); *Eutypella cerviculata* (Fr.) Sacc. (S); *Fenestella princeps* Tul. (S); *Glonium lineare* (Fr.) de Not. (S); *Hypocrea patella* Cke. & Pk. (M); *H. rufa* (Pers.) Fr. (L, M); *Hypomyces aurantius* (Pers.) Tul. (L); *H. lactifluorum* (Schw.) Tul. (M, St); *H. polyporinus* Pk. (H); *Hypoxydon caries* (Schw.) Sacc. (S); *H. cohaerens* (Pers.) Fr. (H); *H. commutatum* Nke. var. *holwayanum* S. & E. (S); *H. fuscum* (Pers.) Fr. (S); *H. Lakei* B. & C. (S); *H. multiforme* Fr. (S); *H. rubiginosum* (Pers.) Fr. (S); *Lasiosphaeria crinita* (Pk.) Sacc. (S); *L. hispidula* (Tode) Fckl. (L); *L. viridicoma* (Pk.) Sacc. (S); *Massaria inquinans* (Tode) Fr. (S); *Nectria cinnabarina* (Tode) Fr. (S); *N. Coryli* Fckl. (L); *N. episphaeria* (Tode) Fr. (L); *Pleurostoma Candollei* Tul. (L); *Rosellinia ligniaria* (Grev.) Nits. (S); *Ustulina vulgaris* Tul. (H, S, T); *Valsa abietis* Fr. (S); *V. pauperata* Cke. & Ell. (L); *Valsaria exasperans* (Ger.) Sacc. (S); *Xylaria corniformis* auct. Amer. not Fr. (S, T); *X. filiformis* (A. & S.) Fr. (S); *X. hypoxydon* (L.) Grev. (L).

DISCOMYCETES: *Caliciopsis pinea* Pk. (S); *Chlorociboria versiforme* (Pers.) Seaver (L); *Chloroscypha Jacksoni* Seaver (L); *Chlorosplenium aeruginosum* (Oed. ex Fr.) de Not. (H, S); *Clithris morbida* (Pk.) E. & E. (S); *Cudonia circinans* (Pers.) Fr. (Wh); *Dasyscypha Agassizii* (B. & C.) Sacc. (L, S, Sn); *Dasyscyphella vitis* (S.) Sacc. (S); *Dermatea acerina* (Pk.) Rehm (Wh); *D. balsamea* (Pk.) Seaver (S); *D. molliniscula* (Schw.)

Cash (S); *Discinella livido-purpurea* Boud. (L); *Godronia Linnaeae* Karst. (S); *Helotium album* Schum. (Wh); *H. citrinum* (Hedw.) Fr. (L); *H. epiphyllum* (Pers. ex Fr.) Fr. (Wh); *H. fastidiosum* Pk. (S, Wh); *H. fraternum* Pk. (L); *H. phyllophilum* (Desm.) Karst. (Wh); *Lachnella corticalis* Pers. ex Fr. (L); *Lachnum ?Arundinariae* Cash (L); *L. leucophaeum* (Nyl.) Karst. (S); *L. virgineum* (Batsch ex Fr.) Karst. (S); *Lasiobolus pilosus* (Fr.) Sacc. (M); *Leotia lubrica* (Scop.) Pers. (L); *Microglossum rufum* (L. v. S.) Underw. (Wh); *Mollisia bene-suada* (Tul.) Rehm (Wh); *M. cinerea* (Batsch) Rehm (Wh); *M. ramealis* Karst. (S); *M. stictella* Sacc. & Speg. (S); *Orbilia coccinella* (Sommerf.) Karst. (L); *O. leucostigma* Fr. (S); *O. xanthostigma* Fr. (S); *Patella scutellata* (L.) Morg. (H); *Paxina macropus* (Clements) Seaver (Sn); *Pezicula acericola* (Pk.) Sacc. (L, S); *P. carnea* (Cke. & Ell.) Rehm. (S); *P. subcarnea* Grove (S); *Phialea cyathoidea* (Bull. ex Fr.) Gill. (S); *P. dolosella* (Karst.) Sacc. (S); *Psilopezia deligata* (Pk.) Seaver (L); *Rutstroemia macrosporum* (Pk.) Kanouse (L); *R. petiolorum* (Rob.) White (Wh); *R. sulfurella* (Pk.) White (L); *Sclerotinia sclerotiorum* (Lib.) deBy. (Wh); *Scodellina leporina* (Batsch) S. F. Gray (H); *Spathularia velutipes* Cke. & Farl. (H, Sn, T, Wh); *Stictis radiata* Pers. ex Fr. (L); *Tympanis fasciculata* Schw. (S).

OTHER ASCOMYCETES: *Adelopus balsamicola* (Pk.) Thiessen (Sn, Wh); *Coccomyces coronatus* (Schum.) Rehm (S); *C. c. var. laciniatus* Schw. (Wh); *Cryptomyces pteridis* (Fr.) v. Hoehn. (M); *Lophodermium melaleucum* (Fr.) de Not. (T); *L. Thujae* J. J. Davis (L, Wh); *Phacidium Vaccinii* Fr. (Wh); *Phyllachora graminis* (Pers.) Fckl. (K); *Plowrightia morbosa* (Schw.) Sacc. (H); *Rhytisma canadensis* Pk. (S, Sn, Wh); *R. ilicis-canadensis* Schw. (H, Sn, St); *R. salicinum* (Pers.) Fr. (Sn); *Taphrina Alni-incanae* (Kühn) Magn. (H, Sn).

LOWER HETEROBASIDIOMYCETES: *Calocera cornea* (Batsch) Fr. (L); *Dacrymyces abietinis* (Pers.) Schroeter (S); *D. deliquescens* Duby (M); *D. palmatus* (Schw.) Bres. (L, M, Sn); *Dacryomitra brunnea* Martin (M); *Exidia nucleata* (Fr.) Burt (L, M); *Gloeotilasma tremelloides* (Wakef. & Pears.) Rogers (M); *Sebacina cinerea* (v. H. & L.) Rogers (M); *S. epigea* (Berk. & Br.)

B. & G. (M); *S. Galzinii* Bres. (M); *S. incrustans* (Fr.) Tul. (L, M); *S. podlachica* Bres. (M); *Stypella minor* Möller (M); *Tremella lutescens* Pers. (H); *T. mesenterica* Fr. (M); *Tremelodon gelatinosum* (Scop.) Pers. (L); *Tulasnella pruinosa* B. & G. (M).

UREDINALES: *Calyptospora Goeppertiana* Kühn [= *Pucciniastrum Goeppertianum* (Kühn) Kleb.] (K, T, Wh); *Chrysomyxa chiogenis* Diet. (Wh); *C. ledi* (A. & S.) deBary (L, S, Sn, Wh); *C. ledicola* (Pk.) Lagerh. (L, Sn, St, T, Wh); *Cronartium ribicola* Fisch. (K, L, Sn, St); *Gymnosporangium aurantiacum* Chev. [= *Ĝ. cornutum* (Pers.) Arth] (H, Ste, T); *Melampsora medusae* Thüm (Sn); *Peridermium balsameum* Pk. (T); *Puccinia angustata* Pk. (K, Si); *P. a. var. typica* Arth. (L); *P. Caricis* (Schum.) Schroet. (L); *P. caricis grossulariata* Arth. (S); *P. Grossulariae* (Schum.) Lagerh. (K, Si); *P. Helianthi-mollis* (Schw.) Jacks. (K, Si); *P. Hieracii* (Schum.) Mart. (S); *P. obtegens* Tul. (T); *P. Poae-sudeticae* (Westend.) Jørstad (K, Si); *P. porphyrogenita* M. A. Curt. (K, L, Si, Sn, T, Wh); *P. Violae* (Schum.) DC. (L, S); *Pucciniastrum americanum* (Farl.) Arth. (K, Si, Sn, T); *P. Goeppertianum* (Kühn) Kleb. (see *Calyptospora*); *P. Myrtilli* (Schum.) Arth. (K, T); *P. Potentillae* Kom. (T); *Uredinopsis mirabilis* (Pk.) Magn. (L, S); *U. Osmundae* Magn. (K, L, M, S, T, Wh); *U. Pheopteridis* Arth. (St); *U. Struthiopteridis* Störmer (Wh); *Uromyces Hyperici* (Spreng.) Curt. (L); *Uromyces striatus* Schroet. (L).

THELEPHORACEAE: *Aleurodiscus amorphus* (Pers.) Rabenh. (H); *A. Farlowii* Burt. (S, T); *Asterostroma ochrostoma* Burt (= *Asterodon ferruginosum* Pat. of the Hydnaceae) (T); *Botryobasidium coronatum* (Schroet.) Donk (L); *B. isabellinum* (Fr.) Rogers (M); *B. vagum* (B. & C.) Rogers (M); *Coniophora olivacea* (Fr.) Karst. (M); ?*C. sistotremoides* (Schw.) Massee (M); *Corticium arachnoideum* Berk. *sensu* Bres. (L); *C. galactinum* Fr. ex Burt. (L, M, Sn, St); *C. livido-caeruleum* (Karst.) v. Hoehn. & L. (M); *C. roseo-carneum* (Schw.) Fr. (St); *C. subpallidum* Litsch. (= *C. calceum* Fr. ex Burt.) (M); *C. sulphureum* (Pers.) Fr. (= *Hypochnus fumosus sensu* Burt) (M, St); ?*C. Tsugae* Burt (M); *Craterellus lutescens* Pers. ex Fr. (or *Cantharellus lutescens* Fr.) (W); *Hymenochaete cinnamomea* Bres. (M);



?*H. spreta* Pk. (M); *H. tabacina* (Sow.) Lév. (H, M, St, T); *Peniophora alutacea* (Karst.) v. Hoehn. & Litsch. (L); *P. argillacea* Bres. (M); *P. carnosa* Burt (M); *P. cinerea* (Pers.) Cke. (M); *P. cremea* Bres. (L); *P. hydroides* Cke. & Mass. (L); *P. longispora* (Pat.) v. Hoehn. (L); *P. piccina* Overh. (M); *P. mutata* (Pk.) Bres. (T); *P. sanguinea* (Fr.) Bres. (M); *P. tenuis* (Pat.) Mass. (L); *Phlebia strigoso-zonata* (Schw.) Lloyd (L); *Porothelium fimbriatum* Fr. (L, M); *Solenia anomala* (Fr.) Fckl. (M); *S. fasciculata* Pers. (H); *S. polyporoidea* Pk. (M); *Stereum fasciatum* Schw. (H); *S. Murrayi* (B. & C.) Burt (M, Sn, St, T); *S. roseo-carneum* (Schw.) Fr. (St); *S. rufum* Fr. (L, St); *S. sanguinolentum* A. & S. ex Fr. (Sn, T); *Thelephora griseozonata* Cke. (M); *T. terrestris* Ehrh. (St); *Tomentella atrorubra* (Pk.) B. & G. (M); *T. botryoides* (Schw.) B. & G. (M); *T. coriaria* (Pk.) B. & G. (L); *T. fuliginea* (Burt) B. & G. (L); *T. olivascens* (B. & C.) B. & G. [= *Hypochnus olivascens* (B. & C.) Burt] (M).

CLAVARIACEAE: *Clavaria amethystinoides* Pk. (L); *C. fusiformis* Sow. (Sn); *Physalacria inflata* Pk. (L, Sn); *Typhula* sp. (Wh).

HYDNACEAE: *Asterodon ferruginosum* Pat. (including *Asterostroma ochrostroma* Burt) (M, T); *Grandinia farinacea* (Fr.) B. & G. (M); *Mucronella aggregata* Fr. (M); *Odontia cristulata* Fr. (M); *O. fimbriata* Fr. (M); *O. stipata* (Fr.) Quél. (M); *Radulum orbiculare* Fr. (Sn, St); *R. quercinum* Fr. (M).

POLYPORACEAE: *Daedalea confragosa* (Bolt.) Fr. (H, St); *D. unicolor* (Bull.) Fr. (Sn, St); *Favolus canadensis* Kl. (H, Sn, St); *Fomes applanatus* (Pers.) Wallr. (H, St, T); *F. conchatus* (Pers.) Gill. (H, St); *F. connatus* (Weinm.) Gill. (Sn, St); *F. fomentarius* (L.) Gill. (H, Sn, St); *F. igniarius* var. *laevigatus* (Fr.) Overh. (L, Sn, T); *F. pinicola* (Sw.) Cke. (H, St); *F. roseus* (A. & S.) Cke. (H); *F. scutellatus* (Schw.) Cke. (S, Sn); *F. subroseus* (Weir) Overh. (H, St, T); *Lenzites betulina* (L.) Fr. (H); *L. saepiaria* (Wulf.) Fr. (H, Sn, St); *Polyporus abietinus* (Dicks.) Fr. (H, Sn, St); *P. adustus* (Willd.) Fr. (H, L, Sn, St); *P. albellus* Pk. (H, L, Sn, St); *P. anceps* Pk. (Sn, St); *P. betulinus* Bull. ex Fr. (H, St); *P. brumalis* Pers. ex Fr. (Sn);

*P. cinnabarinus* (Jacq.) Fr. (H, St); *P. elegans* Bull. ex Fr. (H, Sn); *P. galactinus* Berk. (L); *P. hirsutus* (Wulf.) Fr. (H, St); *P. pargamenus* Fr. (H, Sn, St); *P. perennis* L. ex Fr. (H, Sn); *P. radiatus* (Sow.) Fr. (Sn); *P. resinosus* (Schrad.) Fr. (St); *P. rheades* Pers. ex Fr. var. *vulpinus* (Fr.) Overh. (Sn); *P. semipileatus* Pk. (H); *P. Tsugae* (Murr.) Overh. [= *Ganoderma lucidum* (Leyss.) Karst.] (St); *P. Tulipiferae* (Schw.) Overh. (H); *P. varius* Pers. ex Fr. (St); *P. versicolor* L. ex Fr. (H, Sn, St, T); *Poria euporia* (Karst.) Cke. (S); *P. medulla-panis* (Pers.) Cke. (Sn); *P. nigrescens* Bres. (Sn); *P. prunicola* (Murr.) Sacc. & Trott. (Sn); *P. semitincta* Pk. (St); *Trametes americana* Overh. (H); *T. serialis* Fr. (St); *T. variiformis* Pk. (Sn, St).

BOLETACEAE: *Boletus auriporus* Pk. (M, Sn); *B. badius* Fr. (Sn); *B. felleus* Bull. ex Fr. (Sn); *B. granulatus* L. ex Fr. (M, Sn); *B. niveus* Fr. (--- *B. holopus* Rostk.) (Sn).

AGARICACEAE: *Amanita phalloides* Fr. (H); *Amanitopsis vaginata* Fr. (L, Sn); *A. v.* var. *fulvus* Sacc. (H, L); *Clitocybe laccata* Fr. (H); *Collybia cirrata* Fr. (Wh); *C. dryophila* Fr. (L, H); *C. radicata* (Relh.) Berk. (L); *C. r.* var. *furfuracea* Pk. (H); *Crepidotus applanatus* Fr. (H, Sn, St); *Flammula sapinea* Fr. (H, Sn); *Galera tibiicystis* Atk. (L); *Hygrophorus ceraceus* Fr. (Sn); *H. miniatus* Fr. (H, Sn); *Inocybe lacera* Fr. (H); *Lactarius deceptivus* Pk. (Sn); *L. deliciosus* Fr. (Sn); *L. fuliginosus* Fr. (Sn); *L. subdulcis* Fr. (Sn); *L. torminosus* Schaeff. ex Fr. (T); *Marasmius rotula* Fr. (H); *Mycena corticola* Fr. (H); *M. haematopa* Fr. (H); *Naucoria siparia* Fr. (L); *Panus rudis* Fr. (H, Sn); *P. stypticus* Fr. (H, Sn, St); *Paxillus atrotomentosus* Batsch ex Fr. (T); *P. involutus* Fr. (H, Sn); *Pholiota erinaceella* Pk. (Sn); *Pleurotus candidissimus* Berk. & Curt. (L); *Pluteus cervinus* Fr. (Sn) and var. *albus* Pk. (Sn); *P. nanus* Fr. (Sn); *Russula acruginea* Lindb. (Sn); *R. borealis* Kauffm. (L); *R. decolorans* Fr. (Sn); *R. emetica* Fr. (Sn); *R. fallax* Cke. (Sn); *R. flava* Romell (Sn); *R. foetens* Fr. (L); *R. fragilis* Fr. (Sn); *R. puellaris* Fr. (Sn); *R. rugulosa* Pk. (L); *R. subfragilis* Burl. (Sn); *R. variata* Bann. (Sn); *R. xerampelina* Fr. (Sn); *Schizophyllum commune* Fr. (H, St); *Stropharia semiglobata* Fr. (H); *Tricholoma rutilans* Fr. (Sn); *Trogia crispa* Fr. (St).

GASTEROMYCETES: *Lycoperdon muscorum* Morg. (L); *L. pyriforme* Schaeff. (H, L); *L. subincarnatum* Pk. (T); *L. umbrinum* Pers. (S).

FUNGI IMPERFECTI: *Cladosporium humile* J. J. Davis (P); *Gloeosporium punctiforme* Ell. & Ev. (Wh); *Glomerularia Corni* Pk. (Si); *Helicoma Curtisii* Berk. (L); *Helicomycetes scandens* Morg. (L); *Rhopalomyces elegans* Corde (M); *Septoria acerina* Pk. (L, Wh); *Tropospora fumosa* Karst. (M); *Verticillium Lactarii* Pk. (L).

POST-FORAY COLLECTIONS, Cushing and Friendship, Maine, by Snell.

POLYPORACEAE: *Polyporus fibrillosus* Karst. (on gray birch); *P. perennis* L. ex Fr. BOLETACEAE: *Boletinus cavipes* (Opat.) Kalchbr.; *B. glandulosus* Pk.; *Boletus americanus* Pk.; *B. chromapes* Frost; *B. edulis* Bull. ex Fr.; *B. elegans* Schum. sensu Fr.; *B. granulatus* L. ex Fr.; *B. niveus* Fr. (= *B. holopus* Rostk.); *B. piperatus* Bull. ex Fr.; *B. scaber* Bull. ex Fr.; *B. subluteus* Pk.; *B. versipellis* Fr.; *B. viscidus* L. ex Fr. AGARICACEAE: ?*Amanita bisporigera* Atk.; *A. flavoconia* Atk.; *A. frostiana* Pk.; *Armillaria imperialis* Fr.; *Gomphidius flavipes* Pk.; *Russula alutacea* Pers. ex Fr.; *R. foetens* Fr.; *R. sordida* Pk.; *Tricholoma sejunctum* Fr.

In addition, undescribed species collected by Whetzel and Sproston are recognized as follows: an *Helotium* to be described by W. Lawrence White; a *Coprinus* to be described by Overholts.—WALTER H. SNELL.

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## A LASCHIA ON CABBAGE PALMETTO

VERA K. CHARLES

(WITH 1 FIGURE)

In view of the fact that *Laschia* has always been considered a tropical genus the discovery of a species occurring on cabbage palmetto in Florida is of special interest. As far as our information goes this is the first record for the United States, although species of *Laschia* on palms have been reported from Panama and Cuba. The occurrence on cabbage palmetto has doubtless been overlooked because of its presence on the lower surface of old, fallen, semi-decayed leaves, also to the fact that the fungus shrivels in drying and is therefore inconspicuous. For three successive years during the months of November, December, January and March the fungus has been sought diligently in different sections of Florida, but the only collections made were at the swamp at Old Faithful, about 22 miles east of Orlando, and at Highlands Hammock west of Seabring. Apparently the fungus is rare for during this period hundreds of old, prostrate leaves were examined and only a few collections made. Possibly it occurs more frequently during other months of the year, but if so it seems as if it would have been observed and recorded previously.

The fungus appears as small nearly sessile, orange yellow, honey-comb-like bodies varying from 1.5-4 mm. in width (FIG. 1, A). The shape ranges from nearly circular when young and unexpanded to slightly reniform when mature. With the aid of a hand lens the pores are shown to be hexagonal in shape, conspicuously ciliate, and ranging from 10-20 in number. The specimens shrink and fade somewhat in drying and are then quite inconspicuous as previously mentioned.

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A search of the literature on *Laschia* reveals the necessity for a monographic study of the genus, with particular attention given to microscopic characters. This situation was recognized by Lloyd who had the opportunity to examine material in foreign herbaria, and often found the specimens, particularly the types, too meager or too poor for satisfactory microscopic study. In view of this condition a revision of the genus will be necessary before the true relationship of species can be correctly understood. Lloyd observed (3) "There are in our Index 93 names, mostly described as new species of *Laschia* and there are 16, or 1 out of 6 that appear to us to be good and 4 of them are doubtful." From a limited study of the genus we would take this assertion to be true.

Various interpretations of the genus have been made by different authors, but in most instances little consideration has been given to the microscopic structures. Probably Lloyd had the best opportunity of any investigator to examine and study species of *Laschia* and as a result he had a more intimate knowledge of the true character of the genus and of species. For this reason and because of the clarity of his discussion of the genus we feel it may be of interest and convenience to quote his description of *Laschia* (1).

"*Laschias* are very interesting under the microscope and it appears to me have never been correctly observed. They have two conspicuous and different bodies.

"First, most species have conspicuous color cells, or glands as I call them, usually imbedded in the sub-cuticular tissue, but also sometimes projecting from the surface and edges of the pores. In but few species that I have examined are these glands imbedded in the hymenial layer. The glands are always smooth with more or less deeply colored contents, and of three types. First, ordinary, cuticular, irregular cells, filled with coloring matter. Second, gland-like bodies with a short or long stalk (FIG. 1, *B*) mostly imbedded in the sub-cuticular tissue or edges of the pores, and in only a few species examined by me in the hymenium. Third, long, cylindrical color cells embedded in the tissue.

"Second, cristated cells which are always hyaline and crowned or covered with little processes, and are beautiful objects under the microscope. They have been held to be empty color cells but I think this is an error as the color cells are never cristated. They

are of two types. First, oval cells (FIG. 1, C from Patouillard) (5) crowned with spiny processes, and second, long, cylindrical cells (FIG. 1, B by Miss Wakefield from Lloyd) (1) covered with spiny processes. Some species which are for me true *Laschias* have neither of these bodies."

An exhaustive search of literature and an examination of the specimens in the C. G. Lloyd Mycological Collections and of those in the Mycological Collections of the Bureau of Plant Industry revealed no species which agreed both macroscopically and microscopically with the Florida material. The nearest approach was a sessile form of *L. auriscalpium* Mont. (4) discussed by Lloyd (2). This material was received from Rev. Torrend and described by Lloyd as being of the same color, size and having the same microscopic structure as *L. auriscalpium*. Lloyd believing that the microscopic features were of more importance in the classification of the species than the presence of a stem, considered this a sessile form of *L. auriscalpium* and described it as follows: "Pileus minute 1-1.5 mm. with a short lateral stem of 1  $\mu$ . Surface even, color when dried pale almost white, and when soaked has a pale yellow cast. Cristated cells long, cylindrical, beautifully cristate, found on pileus surface and pore edges. Color glands numerous on pileus, edge of pore and scanty on pore surface. Spores 8-10, hyaline, guttulate." Lloyd further states that the cylindrical, cristate cells are not known to him in any other species. The difficulty with this statement is that so few species have been studied microscopically. Lloyd describes the color of *L. auriscalpium* as pale, almost white, but having a yellow cast when soaked. The Florida material was consistently orange yellow.

Montagne did not mention cristate cells in his description of *L. auriscalpium* but stated that because of the very different structure he was at first tempted to make a new genus under the name of *Myxomyces*. This difference appeared to consist in the presence in the exterior layer of the pileus, of large rounded cells in juxtaposition. Montagne likened these cells to the cells found in the trama of *Russula*, evidently a reference to the vesiculose tissue (4). We would understand these cells to be the gland-like bodies mentioned by Lloyd in his description of *Laschia* (FIG. 1, B). The stalk of these cells is often very short or practically absent, a

condition which doubtless led Montagne to describe them as round cells.

While Lloyd's description of this sessile form (2) suggests the Florida species, the absence of a stipe or occasionally the presence of a rudimentary stipe, the striking color and coronated cells in addition to the cystidia would seem to justify describing the fungus as a new species.

Most species of *Laschia* have been described on dead wood, and so far as we know no species of *Laschia* on palms has been reported from the United States. However, *L. auriscalpium* was described on palms from Cayenne and later reported from Panama and Cuba. *Laschia intermedia* Berk. & Curt. has also been reported on palms from Cuba and Panama. However, Lloyd includes it in a list of species in which the "types" did not exist or were too fragmentary and scanty for any conclusion to be drawn from them. The original description is also too incomplete for a proper understanding of the species. *L. chippii* was described by Lloyd on palm stems, but differs from our material in several respects, especially in the absence of color glands and cristate cells. The species is represented in the Lloyd Collections by 2 specimens collected in Singapore but at different dates.

The Florida fungus discussed in this paper would seem to be clearly different from any known species and is therefore considered as new and described under the name of *Laschia sabalensis*.

***Laschia sabalensis* sp. nov.**

Pileus minute, 1.5-4 mm. membranaceous-gelatinous, applanate, semi-orbicular to reniform, orange-buff fading to light orange yellow (Ridgway), sessile; occasionally subsessile; pores 10-20 in number, ciliate, hexagonal; color glands smooth walled, imbedded in the tissue rarely in the hymenium, broadly cylindrical constricted in the middle, external layer of large rounded cells (vesiculose-like cells of Montagne); cristate cells of 2 types, one type numerous, long, cylindrical with enlarged non-echinulate base, the second type few, broadly oval, apical portion adorned with spiny processes; basidia short, sterigmata, cylindrical; spores hyaline, pyriform, apiculate  $4-5 \times 9-10 \mu$ .

On dead leaves of *Sabal Palmetto*.

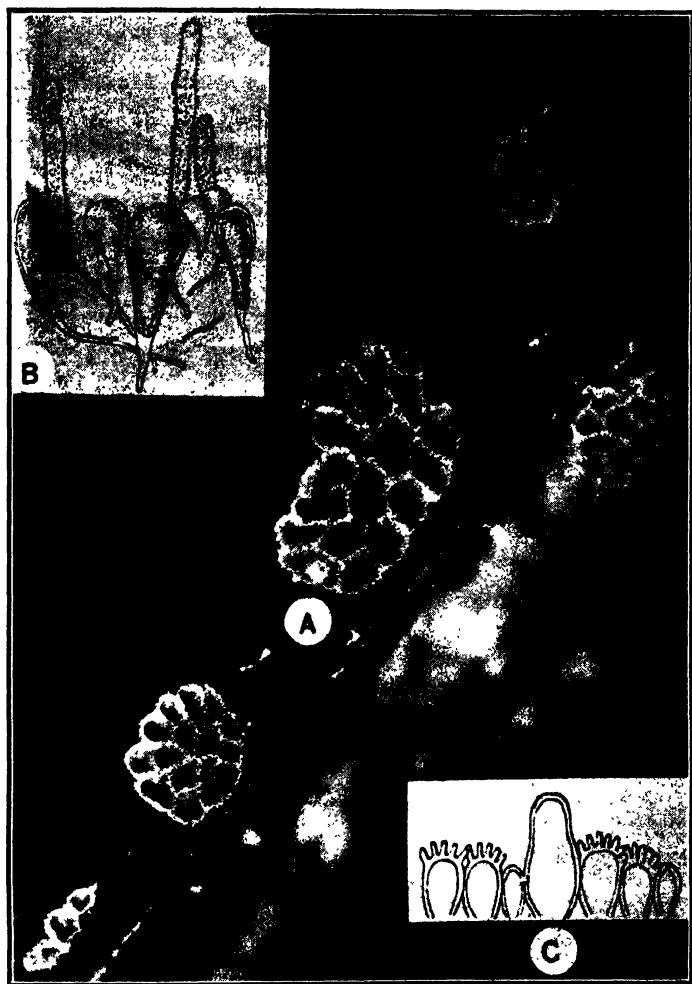


FIG. 1. *A*, fruiting bodies of *Laschia sabalensis* in situ,  $\times 13$ ; *B*, short oval cells and long cristate cells as found in *L. auriscalpium* and *L. sabalensis* (after Lloyd); *C*, section of a gill of *Androsaceus* (*Marasmius*) *haematocephalus* illustrating oval cells with spiny processes such as also occur in *Laschia sabalensis* (after Patouillard).

Pileo minuto 1.5–4 mm. gelatinoso membranaceo, applanato, subrotundato, subreniformi, aurantiaco-luteo, pallescente usque pallide aurantiaco-flavo sessili vel interdum subsessili; poris 10–20, insigne ciliatis, hexagonis; cellulis pigmentatis glabrotunicatis in textura immersis, rare in hymenio, late cylindricis, medio constrictis; cellulis magnis, subsphaericis in strato externo praesentibus, cellulis cristatis bifimbriis, aliis numerosis, longis, cylindricis



basi subbulboso, non-echinato, aliis paucis, late ovoideis, apice solum echinulatis; basidiis sterigmatibus brevis, cylindraceis; sporis hyalinis, piriformibus, apiculatis,  $4-5 \times 9-10 \mu$ .

Hab. in foliis emortuis *Sabal* *Palmetto*.

Type collected at Highlands Hammock, Fla., by V. K. Charles, Mar. 3, 1941. Deposited in the Mycological Collections of the Bureau of Plant Industry, Washington, D. C., No. 71360.

Additional collections:

Myc. Colls. No. 71361 C. L. Shear, Kissimmee, Fla., Nov. 1923.

Myc. Colls. No. 71362 C. L. Shear, Old Faithful, Orange Co., Fla., Dec. 30, 1940.

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BUREAU OF PLANT INDUSTRY,  
WASHINGTON, D. C.

## A NEW MONOBLEPHARELLA FROM MEXICO

LELAND SHANOR

(WITH 20 FIGURES)

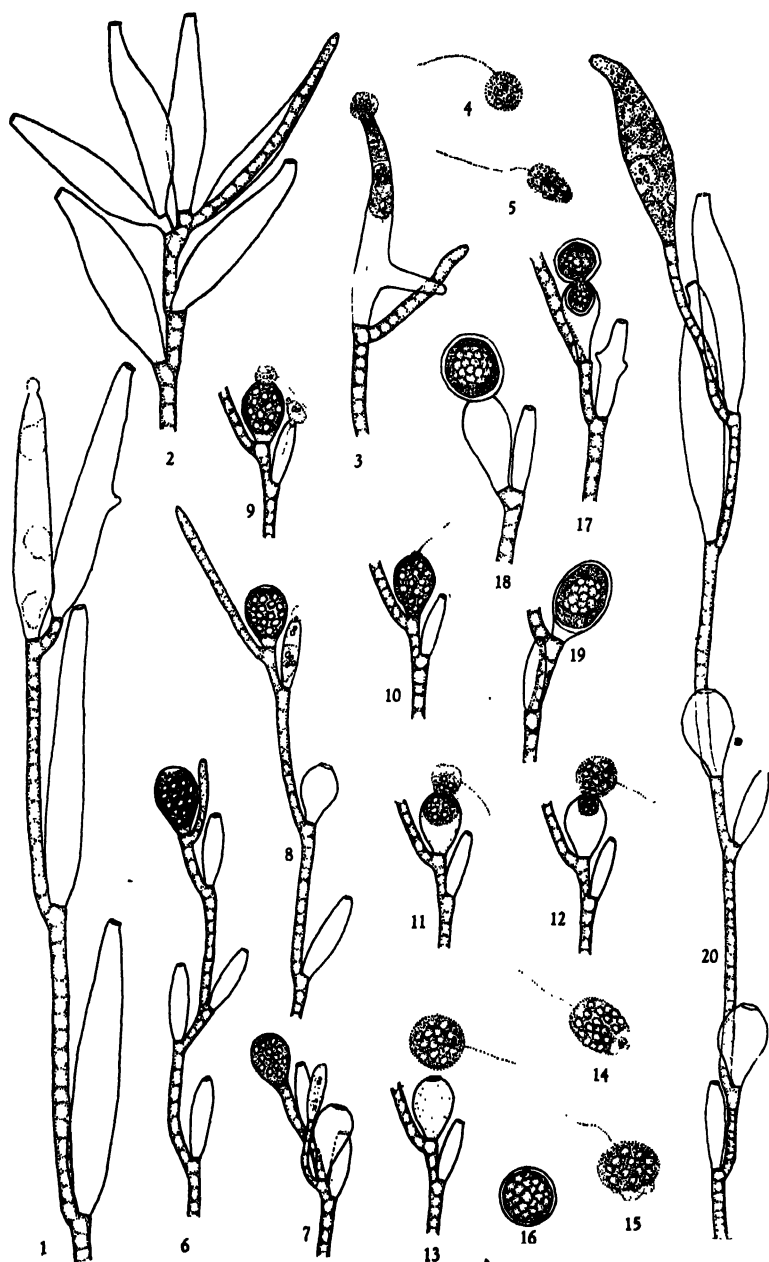
Among other aquatic Phycomycetes recovered by the author from soil samples collected for him in Mexico during the summer of 1941, by William C. Leavenworth and Martha M. Leavenworth of the Fourth Hoogstraal Biological Expedition to Mexico, there appeared a species of *Monoblepharella* heretofore unreported. These soil samples were collected in July and allowed to dry thoroughly at that time, then were carefully packed in separate containers. They were brought to the Botanical Laboratories of the University of Illinois in September where they were placed in jars in sterilized distilled water to which several types of substrata suitable for aquatic Phycomycetes had been added. These bits of substrata were examined at regular intervals and the fungi recovered were isolated and identified each time. Hemp seed in the three jars containing soil samples from stations on the north side of Mt. Tancitaro, State of Michoacan, when examined on November 3, were luxuriantly covered with the pearly gray mycelium of a very delicate fungus. An examination of these hyphae showed that they resembled those of *Monoblepharella Taylori* Sparrow. After cultures had stood on the laboratory table for over ten days and only sporangia appeared on the hyphae, they were placed in a constant temperature oven held at 30° C., a procedure recommended by Sparrow (1940), in an attempt to induce the formation of sexual organs. After three days at this temperature, cultures were found to be producing antherida and oögonia in abundance. The position of the gametangia on the hyphae and their sequence of formation readily distinguish this plant from *Monoblepharella Taylori* and warrant its description as new.

**Monoblepharella mexicana** sp. nov.

Mycelium well developed, hyphae delicate,  $1.5\text{--}5.5\ \mu$  in diameter, much branched, branches usually growing almost at right angles to the main hyphae, contents reticulately vacuolated; sporangia narrowly cylindrical or siliquiform, variable in size,  $40\text{--}95\ \mu$  in length by  $6.5\text{--}10\ \mu$  in diameter at the widest point, occurring singly or in clusters due to marked sympodial branching of the supporting hypha; zoöspores ovoid to subcylindrical,  $6.6\text{--}10\ \mu$  long by  $4\text{--}5\ \mu$  in diameter, posteriorly uniciliate, cilia up to  $36\ \mu$  long; oögonia at first terminal but often becoming lateral due to the sympodial branching of the supporting hypha, obpyriform with somewhat rounded apex and a narrow cylindrical base,  $14\text{--}17\ \mu$  long by  $9\text{--}15\ \mu$  in diameter, tapering to  $2\text{--}4\ \mu$  at the base, containing usually a single egg in which there are numerous large refractive globules; antheridia terminal or after sympodial branching of the supporting hypha appearing lateral, narrowly cylindrical or fusiform,  $14\text{--}16\ \mu$  long by  $4\text{--}6.5\ \mu$  in diameter; antherozoids 2–8, amoeboid, posteriorly uniciliate, ovoid when swimming,  $4\text{--}6\ \mu$  long by  $2.5\text{--}3.7\ \mu$  in diameter, normally containing 2–4 strongly refractive globules; zygote broadly ovoid to nearly spherical,  $10.5\text{--}13.6\ \mu$  long by  $8\text{--}10\ \mu$  in diameter, free swimming or becoming stationary at oögonial orifice; oöspores formed free in the water or within oögonium or at its mouth, normally spherical,  $10\text{--}13\ \mu$  in diameter with a slightly thickened, amber to light brown, smooth wall, contents containing many large refractive globules, upon germination forming a mycelium.

Mycelium amplum, hyphis tenuibus,  $1.5\text{--}5.5\ \mu$  diametro, ramosis; sporangia anguste cylindrica vel siliquiformia, valde variabilia,  $40\text{--}95\ \mu$  longa,  $6.5\text{--}10\ \mu$  diametro, zoosporis ovoideis vel subcylindricis,  $6.6\text{--}10\ \mu$  longis,  $4\text{--}5\ \mu$  diametro, postice uniciliatis, ciliis usque ad  $36\ \mu$  longis; oogonia primum terminale formata, serius quasilaterale, obpyriformibus,  $14\text{--}17\ \mu$  longis,  $9\text{--}15\ \mu$  diametro, cum apice rotundo et basi anguste cylindrico,  $2\text{--}4\ \mu$  diametro; ova singula, cum globulis magnis refractivis; antheridia primum terminale formata, serius quasilaterale, anguste cylindrica vel fusiformia,  $14\text{--}16\ \mu$  longa,  $4\text{--}6.5\ \mu$  diametro, antherozoideis 2–8, amoeboides, postice uniciliatis, ovoideis si natantibus,  $4\text{--}6\ \mu$  longis,  $2.5\text{--}3.7\ \mu$  diametro, cum globulis refractivis 2–4; ova in-seminata late ovoidea vel fere sphaerica,  $10.5\text{--}13.6\ \mu$  longa,  $8\text{--}10\ \mu$  diametro, natantia; oosporis in aqua libere formatis, sphaericis,  $10\text{--}13\ \mu$  diametro, membranis paulo incrassatis sucinaciis vel pallide brunneis, levibus in germinatione mycelium formantibus.

In soil from wet meadow along stream on North side of Mt. Tancitaro, Tancitaro Province, State of Michoacan, Mexico, at an altitude of 10,000 feet, July 24, 1941.



FIGS. 1-20. *Monoblepharella mexicana*.

Slides of preserved material from the type cultures are being deposited in the herbaria of the University of Illinois, the University of North Carolina, the University of Michigan, the Farlow Herbarium of Harvard University, and in the Mycological Collection of the Bureau of Plant Industry, Washington, D. C.

#### OBSERVATIONS

Details of sporangium formation and stages in zoöspore development and discharge in this species are essentially similar to corresponding stages carefully described by Sparrow (1933) for *Monoblepharis*. It would be superfluous to repeat similar details for *M. mexicana*, but there are several points concerning the morphology of this new species that should be recorded.

Globose to somewhat spindle-shaped swellings often are formed at various places on the hyphae. These are considered to be normal structures and not abnormalities caused by the presence of a parasite, as might be suspected. Branches usually arise almost at right angles to the main hyphae. There is regularly no definite relationship between swellings on the hyphae and the position at which branches arise.

Although sporangia are terminal in origin, later they appear in a lateral position due to the sympodial branching of the hypha (FIG. 1, 3, 20). In old cultures the length of the portions of a hypha between sporangia is often so short that they appear to be formed somewhat in clusters (FIG. 2). The apex of a large number of the sporangia is definitely curved (FIG. 1, 3, 20) and pronounced papillate outgrowths often appear at various places along the sporangial walls (FIG. 1, 3). I have never observed any of these functioning in the capacity of exit tubes for the zoöspores regularly escape through a pore at the apex of the sporangium. In contaminated cultures, the largest spores often plug the exit pore so that all remaining spores are trapped within. These germinate later by the formation of germ tubes which penetrate the sporangial wall. From these germ tubes delicate hyphae develop and extend some distance out into the water.

Both oögonia and antheridia originate in a terminal position but later appear to be lateral due to the sympodial branching of the

hyphae on which they are formed. As a rule an antheridium is cut off first at the tip of a hypha which is producing gametangia, with additional sexual organs being cut off from the hypha as it elongates. Several antheridia may be formed in this way before any oögonia are produced (FIG. 6), but most commonly antheridia and oögonia alternate on a branch which bears sexual organs (FIG. 7, 8, 20). In young cultures gametangia are usually spaced some distance apart but often in older cultures they are formed rather close to each other, appearing to be somewhat in clusters (FIG. 7). The antheridium is never cut off in a hypogenous position from the hypha supporting an oögonium as is the case in *M. Taylora*, so the two species are easily distinguished by the position of the male reproductive organs.

The behavior of the gametes during fertilization and of the zygote which results from this fusion is, for the most part, like the behavior of those of *M. Taylora* (Sparrow, 1940). In cultures badly contaminated by bacteria, some of the zygotes frequently either fail to emerge from the oögonium or emerge but do not have a swarming period. In the latter cases the zygote tumbles and turns a few times before finally coming to rest to mature at the oögonial orifice. In these instances the position where oöspores are formed is the same as that considered to be typical of *Monoblepharis* and, were it not for observations on relatively clean cultures, the presence of many oöspores at the mouths of oögonia would give the impression that this species is a *Monoblepharis* rather than a *Monoblepharella*. The motile nature of zygotes, however, is easily observed in cultures in which there is a rather low bacterial population. Even in badly contaminated cultures some of the zygotes undergo a swarming period.

#### DISCUSSION

The oögonia and antheridia of *Monoblepharella mexicana* are similar to the structures suspected of belonging to the sexual stage of *Monoblepharis ovigera* Lagerheim as described and figured by Sparrow (1933, fig. 27 particularly). As a result of observations on *M. mexicana*, the author is of the opinion that Sparrow's original conclusion regarding these structures which he observed was

correct and also that Sparrow's (1940) more recent suggestion that *M. ovigera* should be transferred to *Monoblepharella* is very likely. It would seem advisable, however, to postpone this transfer until *Monoblepharis ovigera* can be reexamined and studied carefully so that the details of the sexual nature of this species can be clearly established.

The marked differences in relative size and shape of the majority of sporangia of *Monoblepharella mexicana* and those of *Monoblepharis ovigera*, apparently would prevent our considering these two as synonymous.

#### SUMMARY

A new species of *Monoblepharella* is described as *M. mexicana*. This fungus was recovered from soil samples collected in a wet meadow along a stream on the north side of Mt. Tancitaro, State of Michoacan, Mexico, at an elevation of 10,000 feet. It is distinguished from *M. Taylori* by the position of the sexual organs on the hyphae and by their sequence of development. In the present species no part of the antheridium ever occupies a part of the supporting hypha cut off directly below an oögonium. Under poor environmental conditions oöspores may be formed in the oögonium or at its orifice as typical for *Monoblepharis*.

DEPARTMENT OF BOTANY,  
UNIVERSITY OF ILLINOIS,  
URBANA

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#### EXPLANATION OF FIGURES

All drawings were made with aid of a camera lucida and are approximately  $\times 567$  as here reproduced.

FIG. 1, portion of hyphal tip from a young culture showing typical arrangement of sporangia; 2, portion of hyphal tip from an old culture showing cluster of sporangia through one of which the hypha is proliferating; 3,

portion of hyphal tip bearing a sporangium with a marked papillate outgrowth; 4, zoospore drawn just at the moment of becoming free from the sporangium; 5, zoospore in swimming condition; the refractive globules are clustered at the anterior end; 6, hyphal tip bearing gametangia; four antheridia were produced in this case before the first oogonium was formed; 7, hyphal tip with group of gametangia as frequently encountered in badly contaminated cultures; 8, hyphal tip showing typical sequence of gametangia; male and female gametangia usually alternate on a hypha in this manner; 9-13, the terminal pair of gametangia shown in figure 8 illustrating further stages in emergence of male gametes, fertilization of the egg, and escape of the zygote; 14, normal motile zygote; 15, an amoeboid zygote; 16, mature oöspore formed free in the water; 17, oöspore formed partly outside and partially within an oogonium; note papillate antheridium; from an old contaminated culture; 18, oöspore formed at oogonial orifice as is typical of *Monoblepharis*; from a badly contaminated culture; 19, oöspore formed within an oogonium; from a badly contaminated culture; 20, portion of a hyphal tip showing gametangia and sporangia; the sporangia developed on the hypha after the culture was removed from the constant temperature oven.



## NOTES ON THE MYCETOZOA—VI

ROBERT HAGELSTEIN

The season of 1941 was a very unsatisfactory one for the development of the fruiting bodies of the Mycetozoa, in fact the most discouraging we have ever encountered. Mr. Rispaud and I spent six weeks collecting in New York, Pennsylvania, Ontario and Quebec, and the same conditions prevailed everywhere. There had been no early spring rains, and during the best months, the occasional showers were followed by long periods of dry weather. Nearly two weeks of intensive search in Ontario and Quebec yielded only 45 species. Often, in years gone by, we have seen that many or more in a single day. The entire season's results were 94 species, yet, not disheartening, as among them was a known species and a recognized variety which we had never collected before. Also, during the Foray of the Mycological Society of America in Quebec, in late August, a new species was found, and described in a recent number of MYCOLOGIA as *Badhamia Dearnessii*.

When conditions are not at their best, we must depend on accidental discoveries and the humor that sometimes accompany them in order to enliven our spirits and enable us to carry on. In early September, our car was parked along a mountain road in the Catskill mountains. On one side was the steep slope of the mountain, and on the other, a deep valley. Our young associate, Bobby, the eleven year old son of Mr. Rispaud, was more intent on chasing butterflies and insects than working, although he gets a small stipend for a good find. A grasshopper lit on the grass along the road. Bobby grabbed with his hand, and on opening it, found no grasshopper but a few stems of weeds. He ran to us exclaiming he had plasmodiocarps, and so it was—he got a nickel. He had beautiful plasmodiocarps of *Didymium anellus* Morg. It seems a road gang had cut the grass and weeds on both sides of the sunny road, removing most of the debris, but leaving a few stems. On

these were more developments of *D. anellus* and several other species, but nothing else was found in the vicinity. Who would ever think of looking over so unpromising a spot? A few years ago, when Bobby was younger, and on a warm day, we stopped our car alongside a large tree in Pennsylvania, and entered the forest. Suddenly, Bobby approached and greeted us with the remark "if you will buy me an ice cream cone, I will show you the biggest *Lycogala* in the world." Sure enough, within reaching distance on the living tree beside the car was a large, perfect aethalium of *Lycogala flavo-fuscum* (Ehr.) Rost. We usually guide a party or two each year to Albertson, our favorite collecting ground on Long Island. On one of these occasions, with fifteen enthusiasts present, not even the scent of a slime mold was noticed—Mr. Rispaud says he can smell them. Disconsolate and apologetic, we rested with the party on the trunk of a large, fallen tree before leaving for our homes. Then, in front of us, 30 feet away and 15 feet above the ground on a living tree, were seen two fine aethalia of *L. flavo-fuscum*. Somebody climbed the tree and got them, because, not like the exaggerative fisherman who always loses the largest one, we always get ours.

Several of the students with whom I have contacts, do not seem to have a clear conception of the differences between *Stemonitis* and *Comatricha* as seen by a rough, superficial examination of the sporangia. In the genus *Stemonitis* the sporangia are cylindrical, and usually long in relation to their breadth. Occasionally the tops are frayed, or attenuate from collapse of the capillitium. Some species of *Comatricha* are similar, but can be separated on other characters by the microscope. If the sporangia are globose or ovoid, the form is a *Comatricha*, and, also generally, if shortly cylindrical, although some species of *Stemonitis* are that way.

In the following notes the year 1941 is meant when no other year is given, and the collections were made by Mr. J. H. Rispaud and myself in company, unless otherwise indicated.

**AMAUROCHAETE FERRUGINEA** Macbr. & Martin. A part of the type material in the Herbarium of the New York Botanical Garden was examined. The specimen is poorly developed and weather worn, and surely not an *Amaurochaete*. There are no signs of a cortex, nor of a confluent or anastomosing capillitium. It consists

of separated sporangia with long stalks and columellae. The stalks are weak and irregular, and recumbent so that the sporangia are intertwined. The spores are the same as those of *Stemonitis splendens* Rost., minutely and closely, but distinctly warted, and a trifle paler than usual. There is no surface net to the weak capillitium. It is the form known as *Stemonitis splendens* Rost. var. *flaccida*. Such forms are often found. N. Y. B. G. No. 6898.

AMAUROCHAETE TRECHISPORA Macbr. & Martin. This is no more than an erratic phase of *Stemonitis trechispora* Macbr. I have seen the latter species forming year after year in many developments at one time, and it is very variable in every particular. An examination of a specimen of *A. trechispora* from the type collection made by Dr. J. H. Faull discloses nothing that may not be found in *S. trechispora*. In a note (Mycologia 28: 615. 1936), I have already mentioned that some collections of *S. trechispora* resemble *Amaurochaete*. It is fallacious to take such a collection and regard it as a species of *Amaurochaete*, which it is not, and which it only resembles. *S. trechispora* must be accepted as a whole, with wide departures on one side to the genus *Amaurochaete*, and on the other toward *Stemonitis fusca* Roth. It is abundant wherever it develops and easily recognized. The principal determinative characters are the habit and habitat as described in the earlier note cited. N. Y. B. G. No. 6897.

BADHAMIA AFFINIS Rost. We have collected this species frequently in areas visited, usually on cottonwood poplar or locust wood, and often in large developments, so that it must be common during certain periods of the season. There is much variation in the form or shape of the sporangia. When seated on short, black stalks, they are flattened or discoid, more or less concave above and beneath. The same shape occurs in sessile sporangia, and there are others subglobose, hemispherical, annulate, curved, or forming short plasmodiocarps. Often several or all of these phases are found in the same development, and again, an entire fruiting may consist of a single phase. The lime in the capillitium may be denser at times, and the lime in the peridium may be so that the wall is smooth or rugulose, or in all gradations to almost limeless. The spores in all our collections are violet-brown, and range from 10-15  $\mu$  diam., generally about 11 or 12  $\mu$ . This is my conception

of the species as described in the 3rd edition of the British Monograph. Miss Lister regards *Badhamia orbiculata* Rex as a variety covering the discoid or flattened forms.

The treatment of the species by Machride and Martin in the *Myxomycetes* is different. They regard *B. orbiculata* as a distinct species, although our collections show flattened, discoid sporangia in the same developments with convex or hemispherical ones. They mention slight differences in size, peridium and capillitium between *B. affinis* and *B. orbiculata*, but these are insignificant and may be noticed in nearly every collection of sporangia with different shapes. Aside from these, the important difference recognized is the size of the spores, which is given as averaging 16–17  $\mu$  diam. for *B. affinis*, citing material collected by Morgan in Ohio with spores up to 18.5  $\mu$  diam. Occasional specimens with an extreme spore range are known, but I doubt they are common. It seems unreasonable to me to regard this as the final, important character of *B. affinis*, particularly as Rostafinski wrote the spore-size of the species, 12.5–15  $\mu$ . The Lister conception of the species covering all ranges of sporangial shape, and with spores 10–15  $\mu$  diam., seems to me to be the proper one.

In my note (*Mycologia* 28: 569. 1936), I advocated the retention of *B. orbiculata* as a distinct species on the ground of unusual sporangial formation by the plasmodium. Much additional material has come since then, and a study of this indicates that the formation is not confined to the discoid sporangia alone, but is more or less common to all shapes of sporangia of *B. affinis*. *B. orbiculata* cannot be regarded as more than a variety of *B. affinis*.

Small portions of a colony of *B. affinis* are often difficult to determine as they may simulate phases of other species of *Badhamia*. A complete fruiting will usually show the all important flattened sporangia, and the small circular or linear depressions characteristic of the species and due to sporangial formation.

**BADHAMIA CAPSULIFERA** (Bull.) Berk. It was gratifying to find this species because it is rare, with only a half dozen or so specimens from eastern North America in the Herbarium of the New York Botanical Garden. The fruiting is very small covering less than two square cm. in area. The sporangia are firmly sessile;

the spores are in clusters, dark, strongly spinulose over two-thirds of the surface only, and measure  $12\ \mu$  diam.

The rarity of collection is probably due to the small size of the developments which are not easily discovered when solitary. The present specimen was found among numerous, small collections of various species of *Badhamia* taken from a pile of fire wood at West Fulton, Schoharie County, New York, in early September. It might have been passed over as not impressive enough to keep. The spores in the species are not always uniformly clustered throughout an entire colony, and may become free in some sporangia. I was satisfied from the appearance of the spores that they should be adherent, but it was necessary to examine several sporangia to find the clusters. In others they were free. N. Y. B. G. No. 2468.

*BADHAMIA CINERASCENS* Martin. Dr. William R. Maxon, of the United States National Museum, has courteously permitted me to examine the type specimen of this form. The development covers about one square cm. of surface, and consists of several dense clusters of grayish white sporangia, some superimposed and others confluent. The clusters appear to be sessile, but the presence of a yellowish hypothallus, with vestiges of yellowish stalks—which may have borne sporangia—indicate that perhaps there are similar stalks below the clusters. This cannot be confirmed without ruining the small amount of material. Some of the sporangia are subglobose, the majority of various irregular shapes, reniforme or elongated, and often compressed. The thin membranous sporangial wall is densely covered with clusters of white lime-granules. The capillitium is clearly that of a *Physarum*, although appearing *Badhamia*-like. It consists of numerous short, hyaline threads connecting many large, angular or branching lime-knots. The spores vary much in shape, size, and even color, in the different sporangia, so that it is somewhat difficult to understand them. The normal shape appears to be spherical, although there are many irregular ones that cannot be fully swollen. The general diameter is about  $12\ \mu$ , with many smaller down to  $8\ \mu$ , and numerous large, spore-like bodies up to  $25\ \mu$  diam. The general color is a dull purplish brown with a tinge of gray, not very dark, besides which there are many spores much paler. These conditions indicate im-

perfect development, and this is borne out by the presence, in some sporangia, of agglutinated spores that come out as a mass with the capillitium, instead of separated as in a perfect development. The spores are spinose, and while dark and prominent, the spines are not long, and can just be seen on the borders of the spores. The spines are arranged irregularly, with smooth areas here and there that have no spines. These areas appear paler by contrast with the dark, adjoining spines, but have the same color as the rest of the spore. Sometimes the areas are linear, and there may be several of these on a spore, or they may cross. They are different on every spore that has them, and are not reticulations, but due entirely to the arrangement of the spines.

The habit, shape of sporangia, capillitium, and spores are characteristic of the tropical species *Physarum reniforme* (Masse) Lister. I have no doubt the specimen is a somewhat imperfect development of that variable species.

*BADHAMIA DEARNESSII* Hagelstein. The species was described in the January–February number of *MYCOLOGIA*. While going over some old material after the description was in press, I discovered that the species was also found at Brassua Lake, Somerset County, Maine, in August 1936. The spores are identical with those of the Quebec collections, having the pale, narrow, spinulose bands around them. N. Y. B. G. No. 3501.

*BADHAMIA PANICEA* (Fries) Rost. The species is far more abundant than the rare *Badhamia macrocarpa* (Ces.) Rost., but so close in some of its characters, at times, that undoubtedly it is often confused therewith. In typical examples the capillitium is coarse, aggregated at the base with a pseudo-columella, and the spores are pale lilac-brown, obscurely warted or spinulose, and about 11–12  $\mu$  diam. In typical examples of *B. macrocarpa* the capillitium is not so coarse, not confluent to form a pseudo-columella, and the spores are dark purplish brown, with thick walls, strongly spinose, and measure 10–15  $\mu$  diam. *B. panicea* has a character which is nearly always present in greater or lesser degree when an entire fruiting is studied. There is a dark red hypothallus, or reddish bases to the sporangia indicating the hypothallus, and occasionally, short, stranded, reddish stalks. Rarely these may be pale yellowish like in *B. macrocarpa*, but in the latter species they are never red. The

capillitium of *B. panicea* may be more delicate, approaching that of *B. macrocarpa*, and the spores are frequently darker in color and more spinulose. Forms with darker spores, and paler on one side belong to var. *heterospora* G. List. which we have found in Schoharie County, New York. Similar spores, not paler on one side, are difficult to distinguish from *B. macrocarpa* unless other characters are present. The habit helps sometimes in making a decision. In *B. panicea* many sporangia may be united and angled by mutual pressure. *B. macrocarpa* often forms small clusters of united sporangia. This is not of great value, however, as more often in both species there are many separated sporangia and the appearance is similar. Neither species has the flattened sporangia of *Badhamia affinis* Rost.

COMATRICHA RISPAUDII Hagelstein. Found again in Pike County, Pennsylvania, in August. The large development was on moss but in poor condition because of age and molds. The species was also collected by Dr. Erdman West near Gainesville, Florida, in June 1940. I had the pleasure of meeting Dr. West in February, 1941, and he took me to the identical spot where the collection was made. It was similar to all other places where the species has been found heretofore, a dry part of a wet area. N. Y. B. G. Nos. 2548, 9351.

CRATERIUM PARAGUAYENSE (Speg.) List. Collected by Dr. Erdman West near Gainesville, Florida, in June 1939. Dr. West says he has found the species on several occasions, and that it appears to be fairly common in Florida, often on fallen Spanish moss. N. Y. B. G. No. 9333.

CRIBRARIA ATROFUSCA Martin & Lovejoy. I have examined a specimen of this form marked cotype 1449, collected by Dr. E. Bethel in Colorado. The specimen consists of very dark, globose and piriform sporangia, the dark color due to the great abundance of the large, dark, plasmodic granules in the calyculus and nodes. The granules in the calyculus form narrow, radiating areas from the base upward, close together, and separated by similar, narrow areas of paler granules. Frequently, there are aggregations of the darker granules in the pale areas, and when these coincide with similar ones in other pale areas, they form areas like rings around the calyculus. They may, however, be interrupted, short, or ir-

regular, and besides there are often masses of dark granules which do not form rings or lines. The spores are brownish, practically smooth, and measure about  $8\mu$  diam.

The general characters of this form, the presence of piriform sporangia, the large plasmodic granules, and the darker spores, are the diagnostic characters of *Cribraria piriformis* Schrad. In the latter species the number of the plasmodic granules varies, sometimes in the same colony, causing darker or paler colors in the sporangia. They may be uniformly distributed so that radiating areas are absent, or they may be densely aggregated in the upper part of the calyculus. In European specimens here, they are massed at the edge to form a broad border around the calyculus. Any sort of variation in the distribution of the granules may be expected, but can hardly be regarded as a basis for a distinct species. *C. atrofusca* is a phase of *C. piriformis*. N. Y. B. G. No. 7122.

**CRIBRARIA DICTYOSPORA** Martin & Lovejoy. I have examined a portion of the cotype of this species (S. U. I. 1436) kindly furnished by Prof. G. W. Martin. The species is based upon the reticulate appearance of the spores, although many do not show this. The reticulations are not raised ridges, nor spines arranged in uniform, reticulate fashion. The spores are warted or spinose, rather difficult to say positively because of the faintness of the markings, although I believe they are spines from their appearance on the borders of the spores. The spines are irregularly arranged in patches, with smooth, spineless areas between the patches. Often the smooth areas are linear, and may then be long, short, broken, crossing, or joined, and forming a roughly appearing coarse reticulation. They are not uniform, and spores with fairly similar markings are rare. It will be seen from this that the real character is the arrangement of the spines, and not the effects it produces.

Spores with a similar arrangement of warts or spines are found in a number of species in other genera, but usually accompanied by other characters which firmly establish the species. While there is nothing otherwise to distinguish *C. dictyospora* from *Cribraria piriformis* Schrad., the character seems to be of sufficient importance in the present genus, where it is unique, and so far unknown



in any other member. Generally, the spores of specimens of *Cribraria*—readily recognized by other characters—are not critically examined by the most refined methods of observation, as these are tedious and time consuming. If later studies should show that the arrangement of spines or warts as seen on the spores of *C. dictyospora* is also present on the spores of other species of *Cribraria*, the importance of the character would be lessened. N. Y. B. G. No. 7125.

*CRIBRARIA LAXA* Hagelstein. The species was found again on leaves at the type locality, Long Island, New York, in July. N. Y. B. G. No. 2080.

*DIDERMA SIMPLEX* (Schroet.) List. A curious and finely developed phase of this species was collected in Pike County, Pennsylvania, in August. The sporangia have the hollow columellae, so often present, besides, in many of the sporangia are long, spiky processes extending from the wall or columella. Many other sporangia have on the outside a dense sprinkling of large, hyaline masses of a mineral nature, which may be lime, although there is no reaction to hydrochloric acid. N. Y. B. G. No. 2563.

*DIDYMIUM STURGISII* Hagelstein. On the wood pile at West Fulton, Schoharie County, New York, previously mentioned, was found in September a fruiting of this species which differs only slightly from those reported from Wayne County, Pennsylvania, in *Mycologia* 29: 397. 1937. The plasmodiocarps are a little thicker and more pulvinate, and there is a tendency to form small, circular sporangia with circumscissile dehiscence. The wood on which it appeared was taken home, and there another development appeared about four weeks later. N. Y. B. G. Nos. 2464, 2485.

*ENERTHENEMA MELANOSPERMUM* Macbr. & Martin. Quite naturally, a proposed new species in the genus *Enerthenema* must bear a general resemblance to *E. papillatum* (Pers.) Rost., the type species, because of the restricted, sharply defined, generic characters. The present form does, but the large, black, robust sporangia with stout stalks, the larger and darker spores, and particularly the large apical discs, larger than many sporangia of *E. papillatum*, entitle it to separation as a distinct species. We have found many developments of *E. papillatum* throughout the eastern states, some of large sporangia, others of small ones, dark or pale

in color, but nothing that approaches *E. melanospermum*. The form comes from our northwestern mountains which have produced *Comatricha Suksdorfii* Ellis & Ev., and the latter bears the same resemblance to *Comatricha nigra* (Pers.) Schroet., that *E. melanospermum* does to *E. papillatum*. N. Y. B. G. No. 7228 (portion of type).

*FULIGO CINEREA* (Schw.) Morg. It is worth while making notes of the time required by different species to go through the entire life cycle under natural conditions. Sometimes this may be observed without outside, confusing, factors. On a pile of decaying plant remains in the rear of Mr. Rispaud's home, appeared on August 10th many aethalia of *F. cinerea*, and on September 6th, new, abundant fruitings again appeared. Other species were not present on either occasion. It is reasonable to assume that this species requires about four weeks to go through the cycle from germination of the spores to maturity of the new fruit. N. Y. B. G. Nos. 2081, 2082.

*KLEISTOBOLUS PUSILLUS* Lipp. Found again in Pike County, Pennsylvania, in August. N. Y. B. G. No. 2592.

*LAMPRODERMA ATROSPORUM* Meylan. The species was found by Dr. J. Walton Groves, at Burnet, Quebec, in May 1939. It was also collected by Dr. C. L. Shear in the Yosemite Valley of California, in August 1915. Both specimens have the characteristic capillitium, dark to the tips, and attached to the sporangial wall. The California specimen has spores which are beautifully reticulated with spines. In the Quebec one, the spines are more or less confluent, forming a broken reticulation of raised ridges, accompanied by spines. N. Y. B. G. Nos. 7248, 9893.

*LAMPRODERMA MUSCORUM* (Lév.) Hagelstein. Two further collections of the species have been made, one at McLeans, near Ithaca, New York, in August 1935, and the other at Angels, Wayne County, Pennsylvania, in July 1941. The sporangia look like those of *Lamproderma scintillans* (Berk. & Br.) Morg., but the spores are marked with large scattered spines, and measure 10–12  $\mu$  diam. N. Y. B. G. Nos. 2608, 3193.

*LICEA CASTANEA* G. Lister. In April and October 1929, we made extensive collections of *Licea biforis* Morg. on the thin, inner, layers of the bark of a dead willow tree near Hempstead, Long

Island. There were fresh developments on each occasion, and the remains of many earlier ones. Much of the material was distributed as Nos. 1382 and 1383.

Last winter, while going over the material again to prepare some more specimens, I came across a single sporangium of an unusual *Licea* among those of *L. biforis*, and careful search revealed a few more perfect sporangia, and many bases of prior fruitings. They are subglobose or lengthened, about the size of the sporangia of *Licea minima* Fries, areolated with prominent lines of dehiscence, and with a dull, chestnut-brown color. The spores are free, globose, almost colorless and smooth, about  $10\ \mu$  diam. In mass they are pale olive-yellow. The sporangia are those of *L. castanea*. They agree in almost every respect with collections of the species made by Prof. Charles Meylan, in Switzerland, except that in the latter the spores range a trifle larger up to  $12\ \mu$  diam. The Swiss collections are also on the inner side of bark. The species differs from the associated *L. biforis* in shape and dehiscence, and in the latter, the spores are distinctly pale yellow, with many spores of a true, ellipsoid shape. N. Y. B. G. Nos. 2103, 2104.

ORCADELLA Wingate, Proc. Acad. Nat. Sci. Phila. 1889: 280. I propose to broaden the genus to include *Orcadella operculata* Wing. l. c., *Orcadella parasitica* (Zukal) Hagelstein comb. nov. (*Hymenobolina parasitica* Zukal Oester. Bot. Zeitschr. 43: 133. 1893) and *Orcadella pusilla* (Lipp.) Hagelstein comb. nov. (*Kleistobolus pusillus* Lipp. Verh. Zool.-Bot. Ges. Wien 44: 70. 1894). It seems unnecessary to maintain a separate genus for each of these species on trivial differences in the fruiting bodies, none of which are more than specific. The important generic characters, in common, are the limeless sporangia with refuse matter in the lower parts of the walls; the absence of a capillitium; and the more or less well-defined lids. They are close to *Licea*, differing in the manner of dehiscence.

*O. operculata*, as first proposed was stalked, but sessile sporangia have since been recorded. The mere presence or absence of stalks is not a generic character. *K. pusillus*, a similar sessile form, differs only in minor characters from *O. operculata*. Likewise with *H. parasitica*, but here we have the observations of Zukal about the unusual behavior of the swarm-cells and plasmodia in

cultivations of the form, and obviously, this was regarded as a generic character. Little is known about the early life history of the great majority of the recognized species of the Mycetozoa, and through later research we may find other species with a life history different from that assumed to be uniform for the group. *Hymenobolina pedicellata* Gilb. (Univ. Iowa Stud. Nat. Hist. 16: 153. 1934) is said by the author to form a single sporangium from each small plasmodium, like *H. parasitica*, and has been doubtfully placed in the genus although the sporangia do not have lids. It is omitted from this proposal, as its position is not certain.

The results of culture experiments are subject to question until fully substantiated. This is shown in the expanding literature on the subject by the different results obtained by different investigators with the same species. When results do show an unusual life history, I cannot agree that this should be considered as defining or limiting generic boundaries. We should confine ourselves to the consistent classification based solely on the characters of the fruiting bodies, which is satisfactory and universally accepted. To make exceptions may in time lead to a classification based partly on a set of constant characters, and partly on another of questionable ones, with frequent changes and consequent confusion, as our knowledge of the early life history increases. Regarded in this light, the three species belong in one genus, *Orcadella*, the first proposed. They are fully represented in the Herbarium of the New York Botanical Garden by natural developments.

*PERICHAENA CORTICALIS* (Batsch) Rost. A few sporangia of var. *liceoides* (Rost.) List. were found on a mossy log at Wevertown, Warren County, New York, in August. They are small, .2 mm. diam., subglobose, somewhat iridescent, yellowish brown. The sporangial wall is single, membranous, translucent, yellow, without granular deposits, and finely and closely stippled or papillose. The capillitium is scanty, consisting of simple, thin, and almost smooth elaters. The spores are yellow, minutely and closely warted, 11  $\mu$  diam.

This specimen undoubtedly belongs in the genus *Perichaena*, and not in *Licea* or *Oligonema*. Its position in the genus is not so clear. These small sessile or stalked *Perichaenas* are found occasionally, and the trouble is not only that they are scarce and in

small fruitings, but they are not constant in characters and differ from descriptions. This is seen again in the present form, which, with its papillose wall resembles *P. vermicularis* (Schw.) Rost. For the time being, it is placed with *P. corticalis*. N. Y. B. G. No. 2470.

**PHYSARUM NUDUM** Macbr. Any student of the Mycetozoa with sufficient field experience knows of the frequent occurrence of limeless forms in some of the calcareous genera. I have seen a number of such in *Physarum*, and occasionally in *Badhamia*, *Didymium* and *Diachea*. Sometimes they can be identified by the company of normal or partly normal sporangia, or the presence of some pronounced character. When this cannot be done, the specimens are thrown away here as worthless. To take one of them and place the stamp of a new species on it, simply because it is limeless and cannot be definitely placed, is absurd. *P. nudum* is merely a limeless phase of some species, perhaps a *Physarum* as the author believed, but not necessarily, and more likely, *Badhamia panicea* (Fries) Rost., as the clustered, angled sporangia, with reddish brown bases and stalks of the latter species are present. *B. panicea* occasionally has limeless sporangia associated with normal ones in the same colony. Unfortunately, there are too many species in the American literature based upon abnormal, erratic or imperfect developments. N. Y. B. G. No. 7379 (portion of cotype).

**PHYSARUM PSITTACINUM** Ditm. In August 1941, and, on an earlier occasion in July 1938, we found developments of this species in Wayne County, Pennsylvania, which have stalks and bases of a tawny yellow color instead of the usual orange-red or vermilion of the typical form. The lime-knots in the capillitium are white, or hyaline and translucent, with only an occasional trace of pale yellow. The specimens are var. *fulvum* List. N. Y. B. G. Nos. 2590, 4891.

**PHYSARUM PUSILLUM** (Berk. & Curt.) Lister. The typical phase of the species appeared in great abundance on nearly every compost or pile of decaying, vegetable rubbish examined in New York, Ontario, and Quebec, during the last days of August. These places are the best collecting grounds for the species, and when it appears, it seems to be everywhere. Usually, other interesting species are on the same piles. In the typical form the

sporangia are not globose, but always more or less flattened or concave beneath, and the stalks are reddish brown. The form is easily recognized by its superficial resemblance to *Didymium xanthopus* (Ditm.) Fries. Many specimens in the Herbarium of the New York Botanical Garden.

**PHYSARUM SUPERBUM** Hagelstein. Collected by Dr. Erdman West at Gainesville, Florida, in June 1940. N. Y. B. G. No. 9418.

**STEMONITIS CONFLUENS** Cooke & Ellis. There are ten collections of the species in the Herbarium of the New York Botanical Garden. Three were made by J. B. Ellis, coauthor of the species, at Newfield, New Jersey, in 1880, 1881, and 1896; another by T. C. Palmer at Chester, Pennsylvania, in 1920; and the others by my associates and me on Long Island, New York, at various localities in 1933, 1935, 1936, and 1941. All the collections are remarkably uniform in appearance and characters. The fructifications, generally, are on the inner side of oak bark where it has sprung away from the trunk of the decaying tree, and appeared usually late in the season, October and November. The species must have a wider range of distribution and should be found elsewhere, as it is conspicuous when discovered, and easily recognized without the aid of a lens.

The plasmodium, when fruiting, divides into small portions, forming many small, almost black tufts of confluent sporangia, from 1 to 10 mm. across, rarely a little larger. The sporangia are 1 to 3 mm. high. The sporangia are usually free at the tops and bases, but connected at the middle by lateral extensions of the capillitia or nets, the extension threads carrying small, membranous discs, which are persistent remains of the otherwise weak peridia, consisting of agglutinated spores and vanishing rapidly after the sporangia have matured. The discs are characteristic of the species. The stalks are usually weak and tortuous, continuing into the sporangia as columellae, either to the tops, or merging into the capillitia. In small colonies, the stalks are sometimes combined so that the entire tuft rests upon a single, thick, compound stalk. The rigid, dark brown threads of the open capillitium merge at the surface into a wide-meshed net, usually complete at the top, but sometimes incomplete at the base. The spores are purplish brown, minutely but distinctly spinulose, 11–12  $\mu$  diam.

The Ellis form is clearly described in the Myxomycetes by Macbride and Martin, and in the North American Slime-Moulds by Macbride. It has not been treated properly in the British Monographs, but this is understandable, as formerly the form was known only from the collections of Ellis. In the first edition, it was regarded as a confluent form of *Stemonitis splendens* Rost., and, while recognized as a species, the idea was continued through the following editions by the remark that it may possibly be a confluent form of *S. splendens*. In the description there is no mention of the dark, almost black color of the colonies, nor of the membranous discs. It says further that the colonies are often several inches across. The spore-size is given as 8–11  $\mu$  diam. The description, without a figure, is too broad, and conveys an impression that it is intended to include other forms which occasionally have confluent sporangia. This is shown by several specimens in the herbarium here, determined by a capable student, which have absolutely no relationship to the form of Ellis, but were placed therewith apparently, because the sporangia are somewhat confluent. The sporangia in these forms are large, brown in color, and have spores measuring about 9  $\mu$ . They are clearly erratic or abnormal forms of something else, perhaps *S. splendens*.

Erratic or abnormal phases are common enough in *S. splendens* and other species of *Stemonitis*. When the sporangia are confluent, and other characters are not clearly those of another species, the inclination is to place them with *S. confluens* under the Lister description. This should not be done unless the other characters of the Ellis form are present. Briefly, these are the small colonies, almost black in color; the persistent peridial discs; and the large spinulose spores. They are constant in all specimens here, and combined, distinguish *S. confluens* from every other species of *Stemonitis*.

**TUBIFERA STIPITATA** (Berk. & Rav.) Macbr. A curious form of this species has come here from Dr. Erdman West, collected at Gainesville, Florida, in September 1938. There are five aethalia of clustered sporangia on long, stout stalks, one of which is 5 mm. high. Among the aethalia are many single sporangia on long, dark, thin, flattened stalks, a stalk for each sporangium. N. Y. B. G. No. 8893.

## MYCOLOGICAL NOTES. VI

C. L. SHEAR

### 23. SPHAERIA PYRIFORMIS Pers. Syn. Fung. 64. 1801

Persoon described this *Sphaeria* as follows:

125. *Sphaeria pyriformis*: sparsa minuta simplex, sphaerulis pyriformi-conicis, ostiolis acutis confluentibus.

Prov. rarius ad ligna exsiccata

Obs. Quoad formam quadantenus cum *Sphaeria subulata* Tode t. 15 f. 117. c congruit, sed basi latior; colore quoque differt, nec non superficie laevi.

It is evident that this description is insufficient for the identification of the plant. One can not be sure whether it is an ascogenous or imperfect form. The application of the name, if it is to be retained, must be determined by type or authentic specimens or its application by subsequent authors. We found 3 specimens so labelled in Persoon's Herbarium at Leiden. All have a question mark. We have had opportunity to examine only one of these microscopically. This was collected by Chaillet in Switzerland and agrees very well with Persoon's description. Microscopic study shows it to be a species of *Camarosporium*, having spores  $21-30 \times 12-16 \mu$ , agreeing well with *C. sarmenticum* Sacc.

Fries (Syst. Myc. 2: 539. 1823) transferred what he supposed to be Persoon's species to *Sphaeronema* with the following description:

10. *S. pyriforme*, peritheciis late conicis acutis laevibus, globulo ovali deciduo aterrimo.

*S. pyriformis* Pers. Syn. p. 64 (Scler. Suec. n. 274).

Sparsum l. gregarium, pusillum, opacum, aterrimum, glaberrimum, basi dilatata adnatum, globulo semper opaco. In ligno exsiccato *Quercus*. Aut. vere. (v.v.).

The specimen in his exsiccati cited (Scler. Suec. No. 274) apparently included more than one species. Jaczewski (Nouv. Mém. Soc. Natur. Moscou 15: 358. 1898) says the specimen of this number he examined was *Dendrophoma pleurospora* Sacc. Von.



Höhnelt (Sitz.-ber. Akad. Wien 122: 286-287. 1913) says the specimen of Fries 274 he examined bore only a species of *Rhamphora* which he calls *R. pyrenophora* (Fries) Höhnelt, but says it is doubtful whether it is different from *R. tympanidispora* Rehm and *R. thelocarpoidea* Höhnelt. Unfortunately we have been unable to examine a specimen of this number.

Schweinitz (Trans. Am. Phil. Soc. II. 4: 247. no. 2139. 1832) reports *Sphaeronema pyriforme* Fries with note "Sub cortice Pyri, Bethl. in libro." A part of his specimen in the Michener herbarium is typical *Rosellinia pulveracea* (Ehrh.) Fuckel.

This name appears in Saccardo (Syll. Fung. 3: 191. 1884) as *Sphaeronema piriforme* Pers. with a copy of Fries' description as given above.

In view of the uncertainty and confusion concerning the proper application of this name it would seem best to drop it for the present at least.

#### 24. SPHAERIA HEMISPHERICA Alb. & Schw.

Albertini and Schweinitz described *Sphaeria hemisphaerica* (Consp. Fung. 51. pl. 8, f. 8. 1805) on decorticated *Fagus*. Saccardo (Syll. Fung. 3: 170. 1884) referred it to *Aposphaeria*? Later (Syll. Fung. 10: 397. 1892) he gives it as *Collonema hemisphaericum* (Alb. & Schw.) Grove, in litt. Grove does not mention this species (British Stem & Leaf Fungi 1: 446. 1935) and we do not know on what specimens he based his opinion that it belonged to his genus *Collonema* which has long fusoid spores, unless it be from Fuckel (Symb. Myc. 400. 1869) where the latter lists *Sphaeronema hemisphaericum* Fries and says *Spermatiiis filiformibus*. Fuckel cites no specimens, but his description certainly does not apply to either Albertini & Schweinitz' or Fries' plants. Grove based his genus *Collonema* on *C. papillatum* Grove (Jour. Bot. 24: 136. pl. 266, f. 5. 1886). According to Saccardo (Syll. Fung. 10: 297. 1892) *Oncosporella* Karst. is a synonym of *Collonema*.

There is a specimen labelled simply "*Sphaeria hemisphaerica* Alb. & Schw. Germany" in Persoon's herbarium. This may have been sent him by Albertini and Schweinitz or collected by Persoon

himself. The specimen is on beech. The pycnidia are dimidiate with a plane ostiole and similar in appearance to the perithecia of *Zignoella*, Section *Trematostoma* Sacc. as typified by *Z. Morthieri*. The spores are  $4-5 \times 3 \mu$ , hyaline, firmly agglutinate, yellowish in mass. No sporophores were seen. This fungus is evidently not congeneric with Grove's type of *Collonema* (*C. papillatum*), which has complete, subglobose pycnidia with a papilliform ostiole and fusoid spores,  $18-19 \times 2.5 \mu$ .

The Persoon specimen is very similar to *Aposphaeria subtile* (Fries) Sacc. as found in Michener's specimen No. 2900 mentioned below and associated with perithecia of *Zignoella*.

Fries described as *Sphaeronema hemisphericum* in Kunze & Schmidt (Myc. Hefte 2: 57. 1923) and later the same year (Syst. Myc. 2: 539. 1923) what he regarded as Albertini and Schweinitz' species and issued specimens in his Scler. Suec. No. 104. Fries' fungus was on pine, and according to several specimens of his number 104 examined, it is a *Zignoella*, which was later described by Fuckel as *Trematosphaeria Morthieri*. Jaczewski (Nouv. Mém. Soc. Natur. Moscow 15: 334. 1898) says he also found the same species on the specimen of Fries' No. 104 which he examined. We find no discussion of this species by von Höhnelt. Grove and Saccardo regard certain species of *Aposphaeria* as pycnidial stages of *Zignoella*.

Assuming that the *Sphaeria hemisphaerica* of Albertini & Schweinitz is the fungus described above from Persoon's Herbarium, it is clear that it is not the plant to which Saccardo, Grove and Fries applied the name, but a pycnidial form for which we have thus far found no satisfactory generic or specific name. It may perhaps for the present as well be left in *Aposphaeria*, as in the case of *Sphaeronema subtile* discussed below, until more complete information can be obtained.

25. SPHAERONAEMA SUBTILE Fries in Kunze & Schmidt, Myc. Hefte 2: 57. 1823

This species was distributed by Fries in his Scleromycetes Sueciae No. 160 on *ligna mucida*. Jaczewski (Nouv. Mém. Soc. Natur. Moscow 15: 353. 1898) examined a specimen of this

number, and found pycnidia, small, superficial, globose, ostiolate, with spores ellipsoid, hyaline. No measurements are given. On a specimen of Fries' No. 160, 1st edition, in Michener's Herbarium from Schweinitz, we find minute, superficial, thin walled, black pycnidia on bleached decorticated, frondose wood, having a slightly yellowish agglutinated spore mass; spores somewhat inequilateral,  $4-5 \times 1.5-2 \mu$ . This is apparently the same as the specimen Jaczewski had. Another specimen of this number from the 2nd edition of Scler. Suec. appears to be the same, but has slightly smaller spores  $3 \times 1.5$ , apparently not quite mature. This would naturally be referred to *Aposphaeria* except for the light colored spores. A specimen apparently identical with Fries' No. 160 found in Michener's herbarium as No. 2900, collected in Pennsylvania and determined as *S. subtile* by Curtis, has associated with the pycnidia good perithecia of a *Zignoella*, very close to *Z. diaphana* Cooke & Ellis, which may be the perfect stage of this pycnidial form.

Fries' original description (l. c.) says *ad ligna mucida*. No host is given. The specimen of his No. 160 described above agrees entirely with his original description. In Syst. Myc. 2: 539. 1923, he gives a fuller description and *Sorbus*, *Corylus*, etc. are given as hosts. Jaczewski refers Fries' plant to *Aposphaeria* as *A. subtilis* (Fries) Sacc. (Syll. Fung. 3: 171. 1884). Von Höhnelt has no note on this species. Bonordron applied this name to an entirely different fungus, *Phoma acuta* Fuckel on *Urtica*, according to Jaczewski (l. c. 343). Fries' species referred to *Aposphaeria* by Saccardo is very closely related if not the same as *Sphaeria hemisphaerica* Alb. & Schw., but neither is a true *Aposphaeria*, either as applied by Berkeley or Saccardo, as already stated. They may be left there, however, until a more satisfactory generic name can be found. As the result of our studies of this material we conclude that *Sphaeronema subtile* Fries is *Aposphaeria subtile* (Fries) Sacc., but not a true *Aposphaeria*, as the pycnidia of this fungus are dimidiate, the basal portion of the pycnidial wall is lacking and the conidia develop from a thin, hyaline sporogenous layer in the wood of the matrix. This is a form intermediate between the true pycnidia of Phomaceae and the dimidiate pycnidia of the Leptostromaceae.

*Aposphaeria* Berk. as usually applied has complete pycnidia and can scarcely be distinguished from *Phoma* as used by Saccardo. In fact, both of the species originally referred by Berkeley to his genus, *A. acuta* and *A. complanata*, are transferred to *Phoma* by Saccardo, and another species, *Phoma pulviscula* Sacc., cited as an example of his concept of *Aposphaeria* (Michelia 2: 4. 1882). As indicated in note 24 above, *Sphaeria hemisphaerica* Alb. & Schw., according to the specimen in Persoon's herbarium, which we believe to be the fungus described by Albertini and Schweinitz and possibly an authentic specimen from them, has the same dimidiata pycnidia so aptly characterized by the specific name.

The *Sphaeronema hemisphaericum* of Fries is not the plant described as *Sphaeria hemisphaericum* by Albertini and Schweinitz, but may be the perithecial stage of that fungus. Fries' plant is the same as *Zignoella Morthieri* (Fuckel) Sacc.

26. ODONTOTREMA Nyl. Not. Sällsk. Faun. Fl. Fenn. Förhand. V.  
2: 249. 1861

This genus was described as follows:

II. ODONTOTREMA Nyl.

Thallus vix ullus distinctus. Apothecia nigra thelotremoideo-lecideina (vel gymnotremoidea) nuda, primo clausa, dein margine (proprio) denticulato-rupto dehiscentia. Forte potius Fungis relegandum genus.

1. *O. minus* Nyl. *Herb. Mus. Fenn.* 91. 1859.

Thallus macula saepe valde dilatata albida vel albido-cinerascente indicatus (vix ullus verus); apothecia sat sparsa parva (vix 0,5 millim. latiora); sporae incolores ellipsoideae simplices, interdum tenuiter 3-septatae, longit. 0,011-15, crassit. 0,006-7 millim., paraphyses graciles. Gelatina hymenea iodo vinose rubens.

Supra lignum abietinum vetustum ad Helsingfors raro; prope Aboam (P. A. Karsten); prope Kajanam (K. P. Malmgren).

Huic generi accedit *Schizoxylon* Pers., tres in Europa offerens species (omnes thecis seriatim polysporis), scilicet *Sch. saepincolam* Pers., *Sch. corticolam* ("Coniangium corticolam" Fr. S. V. Sc. p. 121, "Lecideam dryinam" Fr. L. S. exs. 273) et *Sch. dryinum* (Flk. D. L. 141 sub nomine "Lecidea dryina"). Ex iis modo *Schizoxylon corticola* e Scandinavia mihi cognitum, differens sporis minoribus (latit. et longit. circa 0,0025 millim.) a *Sch. dryino* (in quo sporae long. 0,009-0,012, crass. circa 0,0025 millim.). Sed potius fungis adscribendae sint hae species quam lichenibus."

Butler (Mycologia 32: 811. 1940) says *Patellaria minor* Karst.

(Myc. Fenn. 1: 233. 1871) is a synonym. We have been unable to verify this.

Von Höhnelt (Ann. Myc. 15: 306. 1917) discusses the type species, *O. minus*, and gives a description, but does not say on what specimens it was based. He states that the fungus arises in the outer woody fibers of gray wood and has a dark brown excipulum 20–30  $\mu$  thick at the base to 60  $\mu$  at the margin; hypothecium hyaline, 6–8  $\mu$  thick. Epithecium none. The cover opens with very regular teeth and bears on the under side a “quellschicht” or swelling layer. The ascus layer is plano-concave and sharply divided from the cover at the margin. He says it should go in the Phacidiales, in which opinion we concur, after comparing it carefully with *Phacidium lacerum* Fries which has the same peculiar structure of the cover; the swelling layer being made up of parallel hyphae arranged vertically.

Nannfeldt does not agree with von Höhnelt and doubts his opinion that the cover of the fungus has a swelling layer which absorbs moisture and causes it to spread and rupture. We note, however, that in a closely related species we have found on *Zea Mays* and which is apparently unnamed there is the same structure, and that the layer of vertically parallel hyphae on the under side of the cover does function exactly as stated by von Höhnelt. Sections of dried specimens show these hyphae to be thin, parallel and uniform in size. After soaking in water for 5 minutes they become much enlarged and clavate at the lower end, thus causing the cover to burst open and the segments to turn backward. In young specimens, when the asci are beginning to develop, the interior of the apothecium is found to consist of a continuous layer of parallel hyphae which extends from the very thin hypothecium to the inner surface of the cover. As the fungus develops the outer ends of these hyphae become very dark colored. As the asci develop and mature the layer of parallel hyphae ruptures transversely just above the ends of the asci and the lower portions remain as paraphyses, producing short irregular branches which form a very thin, light flesh colored epithecium.

We have seen no authentic specimens of Nylander's species but specimens distributed under No. 368 by Rehm in his *Ascomyceten Exsiccata* as *O. minus* Nyl. with a question mark, on bare wood of

*Larix europaea* in the Tyrol in August 1876, agree entirely with the original description and also with that of von Höhnelt. The spores are hyaline, 1-3 septate,  $9-13 \times 4-5 \mu$ . The characteristic swelling layer is present in the cover.

Von Höhnelt (l. c.) discusses 7 other species which have been included in *Odontotrema* and decides that none of them is congeneric with the type, *O. minus*. If we accept von Höhnelt's account of the type and the presence of a swelling layer in the cover of the apothecium as one of its essential characters many of the other species now included will probably be found to belong elsewhere. This can not be positively determined until the presence or absence of the swelling layer in each is decided.

*Sphaeropezia* would become a synonym of *Odontotrema* if the type of the genus which has not been seen by von Höhnelt or others should be found to possess a "quellschicht," as no other character of generic value is described. *S. Arundinariae* Cash (Jour. Wash. Acad. Sci. 30: 300. 1940) has a typical "quellschicht" as does the apparently undescribed species of *Odontotrema* on *Zea Mays* mentioned above. Single ascospore cultures of this latter form never produced spores of any kind on cornmeal agar.

## 27. ODONTOTREMA HEMISPHAERICUM (Fries?) Rehm

This is supposed to be *Stictis hemisphaerica* of Fries (Syst. Myc. 2: 196. 1822) which he says occurs on "pine &c." He lists it also in Summa Veg. Scand. 373. 1849, but no specimens are cited in either place. In the description of the genus he describes the spores as "vulgo uniseptat." It is not to be inferred from this that he had examined the spores of this particular species, as he lists ten, of which his *S. hemisphaerica* is the second.

Von Höhnelt (Ann. Myc. 15: 308. 1917) says this species is entirely (völlig) different from Nylander's type of *Odontotrema*, and makes it the type of a new genus *Xylopezia*. He based this conclusion upon an examination of a specimen of Fuckel's *Xylographa hemisphaeria* (Fries) in Fung. Rhen. Ex. No. 2673, which he says shows great similarity to *O. minus*, but does not belong to the same genus. He does not state whether he found any "quellschicht" in this specimen or not. Unfortunately, we have seen no

specimen of Fuckel's No. 2673. There is, however, a specimen from Fuckel's herbarium at Geneva, No. 1099 on *Pinus Cembra*, collected by him at Johannesburg, Switzerland, and originally referred to by him (Symb. Myc. Nachtr. 3: 27. 1875), as *Xylographa hemisphaerica* (Fries). The specimen of this number in the Mycological Collections of the Bureau of Plant Industry, shows mostly *Xylographa parallela*. There are, however, a few young ascocarps of his *X. hemisphaerica*, but only immature non-septate ascospores could be found. The young ascocarps have the same structure and appearance as described by von Höhnelt, but no "quellschicht" was found.

Rehm distributed in his *Ascomycetes Exsiccati* No. 286 as *Trematosphaeria excellens* Rehm n. sp. two collections: (1) on decaying "fichten" (*Picea excelsa*) gathered in the Bavarian Alps by Arnold; (2) on decaying trunks of *Pinus Cembra* in the Tyrol, collected by himself. Both of these specimens lack the swelling layer found in the cover of typical *Odontotrema*, and are referred by von Höhnelt to his new genus *Xylopezia*. No. 1 has spores hyaline, 1-3 septate,  $10-12 \times 4-5 \mu$ ; No. 2 has spores identical in shape and appearance, but only  $8-10 \times 3-4 \mu$ . The latter specimen does not seem to be quite mature, as free spores were difficult to obtain, and that may account for the difference in size of the spores. Later Rehm cites these specimens of *T. excellens*, No. 286, 1 and 2, as typical *O. hemisphaericum* with the following synonymy:

ODONTOTREMA HEMISPHAERICUM (Fries) Rehm, Krypt.-Fl.

Deutsch. II. 1<sup>a</sup>: 205. 1888.

*Stictis hemisphaerica* Fries, Syst. Myc. 2: 196. 1822.

*Xylographa hemisphaerica* Fuckel, Symb. Myc. Nachtr. 3: 27. 1875.

*Winteria excellens* Rehm, Ber. Nat. Ver. Augsb. 26: 72. 1881.

*Zignoella excellens* Sacc. Michelia 1: 347. 1878.

Exsicc.: Fuckel, Fungi Rhen. No. 2673, Rehm, Ascom. No. 286.

Rehm states in a note following his description that he agrees with Fuckel in believing that this is the plant Fries described although only 1-celled spores are mentioned, which is often the case

in immature specimens. He says it is not a *Pyrenomycete*, as Winter states, but only simulates one before it is mature and that the species is very close to *Odontotrema minus*, but is distinguished by being finally erumpent and having larger apothecia, and it would be possible to think of them as belonging together. The erumpent or superficial appearance seems to be due to age and weathering of the substratum. The apothecia are rather variable in size in the same specimen. Von Höhnelt (Sitz.-ber. Akad. Wien 118: 1209. 1909) says that *Zignoella excellens* (Rehm) Sacc. is only a form of *Odontotrema hemisphaericum* (Fries) Rehm. Nannfeldt (Morph. Syst. Disc. 212. 1932) says *Odontotrema* Nyl. (type *O. minus*) does not belong to the Phacidiaceae. Fries cites no specimen of his species in *Systema Mycologicum Summa Vegetabilium Scandinaviae*, p. 373, and unless authentic specimens can be found Fuckel's specimens cited above may be accepted as representing the species.

The life cycle and morphology of this and related species need thorough study in order to determine their exact generic character and relationships. Two or three species have been collected on decorticated, coniferous wood and also on *Salix* and *Populus* in subalpine localities of Colorado, but their specific identity is somewhat doubtful.

## 28. CLYPEOTHECIUM Petr.

This was described by Petrak (Ann. Myc. 20: 192. 1922) with the monotype *C. Weirii* Petr. The type specimen is J. R. Weir's No. 16638 on cedar (*Thuja plicata*) collected at Kooskia, Idaho, May 29, 1920. Weir's No. 16610 on *Abies grandis*, from Orofino, Idaho, is also cited. There is abundant material of both these numbers in the Mycological Collections of the Bureau of Plant Industry, as well as Weir No. 16665 on *T. plicata* from Clearwater, Ida., and Weir No. 16605 on *A. grandis*. A study of these specimens shows that they are all *Zignoella Morthieri* (Fuckel) Sacc., which is a rather variable species, especially in size of perithecia and size and septation of spores. The ascocarps are described as single perithecia each covered with a clypeate stroma. Their superficial appearance is that of a depressed subglobose or elliptical peri-



thecium on the surface of decorticated wood. A vertical section shows that it is dimidiate, the ascogenous layer at the base having no distinct wall.

This is not a true *Zignoella* as described by Saccardo (Michelia 1: 346. 1878). He divided the genus into 2 sections, the first with 19 species (3 doubtful) and the second with 8 species. As the type we have chosen *Z. pulviscula* (Curr.) Sacc., which is the second species in the section *Eu-zignoella* of Saccardo (Syll. Fung. 2: 214. 1883) and one of the best known species. This has complete separate perithecia and is quite different from *Z. Morthieri*, which was placed in a subgenus, *Trematostoma* (Sacc. Syll. Fung. 2: 222. 1883) and may be regarded as typical. It is unfortunate that Petrak did not recognize that the Weir specimens were congeneric with Saccardo's subgenus *Trematostoma* and raise it to generic rank, instead of making a new name. According to present rules, subgeneric names do not have priority and in order to adopt *Trematostoma* which is the preferable name, we propose that it be given generic rank and conserved with **T. Morthieri** (Fuckel) Shear, comb. nov. as its type.

It is evident from the structure of this plant, that it is not a true member of the Sphaeriaceae. Petrak (Ann. Myc. 21: 281. 1923) says it is near *Melomastia* having a dothideaceous structure nearly related to the Pleosporaceae. Much more knowledge of the life cycles and morphology of this and related genera is necessary before any satisfactory family distinctions can be drawn.

Most of the species of *Zignoella* referred by Saccardo to his subgenus *Trematostoma* are very similar, and some of them are known to be synonymous. The type, *Z. Morthieri*, is usually found on decorticated and bleached wood of coniferous trees. The perithecia and spores are variable in size, shape and septation, depending on their age and condition of development. A specimen in Thüm. Myc. Univ. Exs. No. 167 gathered by Morthier in Switzerland on *Abies* in 1875 has hyaline, 3-septate spores,  $22-25 \times 6-8 \mu$ . Berlese (Icon. 1: 98. 1894) gives  $24-27 \times 7-8 \mu$  and says *Sphaeria albocincta* Cooke & Ellis, according to authentic specimens, is the same. Von Höhnelt (Mitt. Bot. Inst. Tech. Hch. Wien 4: 44-46. 1927) examined a specimen of this in Ellis and Everhart's North American Fungi No. 1198, and also says it is

the same as *T. Morthieri*. *Sphaeria diaphana* Cooke & Ellis Grevillea 5: 53. 1876, according to an authentic specimen we have examined, differs only in slightly smaller ascospores  $18-20 \times 6-7 \mu$ . The spores in *T. Weirii* according to Petrak are  $22-30 \times 6-10 \mu$ . The extremes here are slightly larger than usual in *T. Morthieri*. *Zignoella soluta* (Cooke & Ellis) Sacc., with spores  $17-20 \times 6-7 \mu$  can scarcely be more than a mere form of the same species.

The synonymy according to our present information is as follows:

**Trematostoma Morthieri** (Fuckel) Shear, comb. nov.

*Trematosphaeria picastra* Fuckel, Symb. Myc. 162. 1869? non Fries.

*Trematosphaeria Morthieri* Fuckel, Symb. Myc. Nacht. 1: 306. 1871.

*Leptosphaeria picastra* Fuckel ex Höhnelt. Mitt. Bot. Inst. Techn. Hoch. Wien 4: 44. 1927.

*Sphaeria diaphana* Cooke & Ellis, Grevillea 5: 53. pl. 80, f. 15. 1876.

*Sphaeria albocincta* Cooke & Ellis, Grevillea 7: 9. 1878.

*Sphaeria soluta* Cooke & Ellis, Grevillea 5: 54. pl. 80, f. 16. 1876 (as "solutae").

*Zignoella albocincta* (Cooke & Ellis) Sacc. Syll. Fung. 2: 224. 1883.

*Zignoella diaphana* (Cooke & Ellis) Sacc. Syll. Fung. 2: 220. 1883.

*Zignoella soluta* (Cooke & Ellis) Sacc. Syll. Fung. 2: 216. 1883.

*Zignoella Morthieri* (Fuckel) Sacc. Michelia 1: 347. 1878.

*Clypeothecium Weirii* Petrak, Ann. Myc. 20: 182. 1922.

Other closely related species are *Zignoella minutissima* (Karst.) Sacc., *Z. jurana* Sacc. & Berl., *Z. translucens* Karst., and *Z. minutissima* subsp. *clavispora* Karst. Some of these are apparently synonymous according to the descriptions, but must await the study of authentic specimens for final decision.

# NEW SPECIES OF ACAULOPAGE AND COCHLONEMA DESTRUCTIVE TO SOIL AMOEBAE

CHARLES DRECHSLER

(WITH 6 FIGURES)

In continuation of observations on biotic relationships of soil microorganisms often revealed in agar plate cultures that after being well permeated with oömycetous mycelium have received some addition of decaying vegetable material, 3 conidial Phycomycetes apparently not hitherto described have been found destroying particular species of terricolous amoebae. Two of the phycomycetous forms are presented herein as new members of the predaceous genus *Acaulopage*, while the third is set forth as a new member of the parasitic genus *Cochlonema*. Further, a rather pronounced morphological variant of *C. bactrosporum* Drechsl. (5) is described as a new variety of that species; and occasion is taken to report supplementary findings pertaining to the vegetative stage of *Acaulopage tetraceros* Drechsl. (2), and to the asexual reproductive stage of *Stylopage cephalote* Drechsl. (4).

## A SPECIES OF ACAULOPAGE PRODUCING CONIDIA BESET WITH STUBBLY APPENDAGES

Several maize-meal-agar plate cultures that after being permeated with mycelium of *Pythium splendens* Braun had been planted with small quantities of leaf mold collected near Beltsville, Md., early in January 1941, showed on cursory examination four weeks later scattered conidia bristling with stubbly appendages. In their scant distribution on the surface of the medium, as well as in their unusual ornamentation, the spores bore a suggestive resemblance to the conidia of *Acaulopage acanthospora* Drechsl. (4). It was not surprising, therefore, that on closer scrutiny they were found to arise from a sparse unseptate mycelium to which were attached

here and there specimens of a naked rhizopod undergoing expropriation of protoplasmic contents.

The rhizopod which thus served the sparse mycelium as food supply, apparently to the exclusion of other nourishment, varied in width between  $10\ \mu$  and  $40\ \mu$  when drawn into a somewhat rounded shape. When moderately extended the larger individuals often measured between  $50\ \mu$  and  $55\ \mu$  in length. Some, though not all, of the newly captured animals revealed from 5 to 10 vacuoles, which from their successive enlargement and contraction appeared to operate as contractile vacuoles (FIG. 1, *A*). Occasionally a few rather small subspherical bodies could be distinguished within an animal, but more frequently no structure having any similarity to a protozoan nucleus was recognizable in the peculiarly turbid, almost opaque, very finely and densely granular, yellowish protoplasm. In newly captured prey, whose normal structure had not yet been noticeably affected, a pellicle could hardly be made out, though the presence of a somewhat firm enveloping membrane was indirectly betrayed through the adhesion of the animal to one or more minute deposits of yellow substance secreted by the hypha. The haustorial system which soon came to be extended inward from each place of adhesion likewise was at first either indiscernible or only faintly discernible (FIG. 1, *A*; *B*; *C*, *a*, *b*; *D*). However, as the contents of the prey became more and more attenuated, the haustorial system emerged with increasing clearness, and surrounding it the pellicle became visible as a faint contour (FIG. 1, *E*, *a*, *b*; *F*, *a*, *b*; *G*; *H*; *I*). With respect to branching habit the haustorial system was essentially of the rangy arbuscular type, but owing to unusually prolonged extension of the assimilative branches in the more distant portion of the animal these branches converged and overlapped distally in such manner that in profile they presented a characteristic intertangled appearance alien to the haustoria of any predaceous fungus yet described. Once the animal's protoplasm had been completely absorbed, the protoplasm of the haustorial system was withdrawn backward into the parent filament, and soon all vestiges of the rhizopod and of the ramifying apparatus that encompassed its destruction were lost to view.

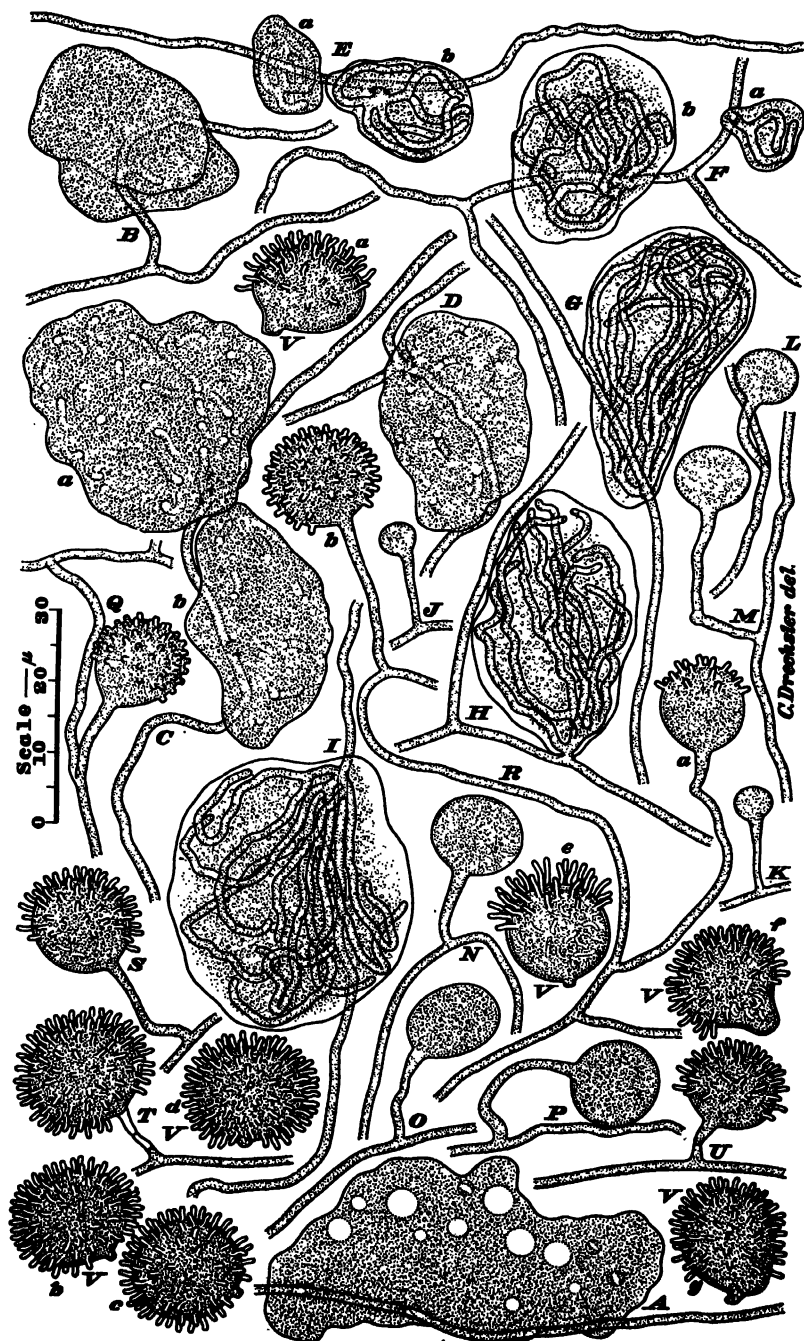
The fungus initiated asexual reproduction by giving rise here and there to relatively short hyphal branches, each of which became

enlarged terminally to form a subspherical body on the surface of the culture medium. During its growth this body remained smooth (FIG. 1, *J-P*), but after attaining definitive size it put forth numerous digitate protuberances from all portions of its surface exposed to the air. Naturally these protuberances while actively elongating contained protoplasm (FIG. 1, *Q*), which, however, was promptly withdrawn when elongation came to an end (FIG. 1, *R*, *a*, *b*; *S*). A septum was now laid down in the short supporting branch to delimit the spherical body as a conidium. Evacuation of a short stalk-like part above the septum occasionally left the spore with a small empty basal appendage (FIG. 1, *T*), but much more often the proximal end was marked only by a pedicellate protrusion (FIG. 1, *U*; *V*, *a-g*).

Despite obvious similarities, the conidia thus formed differ conspicuously from those of *Acaulopage acanthospora*. In the present fungus the empty appendages, instead of tapering perceptibly, maintain a virtually uniform width from base to blunt apex. When the spore is viewed laterally the number of digitations directly visible in upper aspect and in profile varies commonly from about 15 (FIG. 1, *R*, *a*) to about 75 (FIG. 1, *V*, *d*); wherefore the total number, including those concealed underneath, probably ranges from 25 to 125, rather than from 7 to 18 as in *A. acanthospora*. Again, in the present fungus the digitations sometimes are distributed only over a distal region of limited extent, and at other times are distributed over the entire surface of the conidium; whereas the tapering appendages of *A. acanthospora* are distributed more constantly over the distal hemisphere of the spore. The fungus predaceous on the yellowish amoeba undoubtedly represents a separate species, which according will be described as new under a name meaning in part "rough" or "shaggy."

#### ***Acaulopage lasiospora* sp. nov.**

Mycelium sparsum, parce ramosum; hyphis incoloratis, aliquantum flexuosis, .9-1.4  $\mu$  crassis, ad animalia minuta inhaerentibus, pelliculam cujusque capti perforantibus, haustorium (subinde 2 vel 3 haustoria) intus evolventibus quod protoplasma exhaurit; haustorio ex 2-15 ramulis 10-50  $\mu$  longis, 1-1.3  $\mu$  crassis, saepius recurvis et inter se intricatis constante. Ramuli fertiles saepius 5-40  $\mu$  longi, interdum repentes, conidia singulatim super materiam subjacentem ferentes; conidiis hyalinis, saepe aliquantum pedicellatis,

FIG. 1. *Acaulopage lasiospora*.

quoque ex cellula viventi et 25–125 appendicibus vacuis constante; cellula viventi globosa vel aliquid applanata, plerumque 12–16  $\mu$  longa, 11–16  $\mu$  lata; appendicibus 1.5–4  $\mu$  (plerumque circa 2  $\mu$ ) longis, .6–.7  $\mu$  crassis, cylindratis, rectis vel leniter curvatis, apice abtusis vel truncatis, nunc ubique circum cellulam viventem nunc tantummodo in parte supera ejusdem positis.

Amoebas flavidas vulgo 10–40 latas capiens consumensque habitat in humo silvestri prope Beltsville, Maryland.

Mycelium sparse, sparingly branched; vegetative hyphae colorless, somewhat flexuous, .9 to 1.4  $\mu$  wide, capturing minute animals through adhesion, perforating the pellicle of each captive, and extending into it a haustorium (or sometimes 2 or 3 haustoria) to appropriate the protoplasmic contents; haustorium bush-like, with 2 to 15 branches, which vary from 10 to 50  $\mu$  in length and from 1 to 1.3  $\mu$  in width, and which often recurve distally to appear as if intertangled. Fertile branches often 5 to 40  $\mu$  long, sometimes prostrate, each bearing terminally a single conidium on the surface of the substratum; conidium hyaline, consisting of a living cell densely filled with protoplasm, subspherical or often oblate ellipsoidal in shape, mostly 12 to 16  $\mu$  long and 11 to 16  $\mu$  wide, usually somewhat pedicellate at the base, beset everywhere or sometimes only in its distal portion with empty digitate appendages; the latter from 25 to 125 in number, 1.5 to 4  $\mu$  (mostly about 2  $\mu$ ) long, .6 to .7  $\mu$  wide, cylindrical or slightly curved, obtuse or truncate at the tip.

Capturing and consuming amoebae yellowish in color and commonly 10 to 40  $\mu$  wide, it occurs in leaf mold near Beltsville, Md.

#### A SPECIES OF ACAULOPAGE WITH LATERAL CONJUGATION

An agar plate culture which after being permeated with *Pythium* mycelium had received some addition of decaying grass detritus gathered near Beltsville, Md., early in January 1941, showed on microscopic inspection 24 days later numerous slender erect conidia provided individually with a withered distal appendage—the bristling display offering general similarity to a sporulating tract of *Acaulopage rhinospora* Drechsl. (2). However, the mycelium from which the conidia arose (FIG. 2, A–F) was noticeably coarser than that of *A. rhinospora*, although the hyphae composing it tapered to widths of only .6  $\mu$  or .7  $\mu$  in their terminal portions (FIG. 2, G). These hyphae subsisted, apparently to the exclusion of other nourishment, on amoebae varying from 10 to 40  $\mu$  in diameter when drawn into an approximately round shape; the protozoans being captured through adhesion to minute deposits of a

yellow substance. Owing to turbidity normal to the animal's sarcode, details of nuclear structure could not be made out in newly captured specimens. After its invasion by a haustorium bearing on a narrow stalk several wider digitate branches, and consequent to the ensuing depletion of its protoplasmic materials, the captive usually came to reveal internally a prolate ellipsoidal structure containing 3 to 6 bodies in peripheral positions (FIG. 2, *A, n; B, n; C, n; D, n; E, an, bn*). This structure probably represented the animal's nucleus, perhaps modified in some degree by incipient pathological changes, though its continued functional capacity was manifested in prolonged operation of the contractile vacuole (FIG. 2, *A, v; B, v; C, v; D, v; E, av, bv; F*). Later the structure disintegrated, and its materials together with remnants of cytoplasm were assimilated by the fungus. Thereupon the contents of the haustorium were withdrawn into the parent hypha; and the empty haustorial membrane, as well as the collapsed pellicle surrounding it, was soon lost to view.

Development of asexual spores was initiated by the production of erect aerial processes from the mycelial hyphae extended on the surface of the culture medium (FIG. 2, *G-I*). On reaching full stature (FIG. 2, *J, a*) the individual process showed noticeable constriction about  $1\mu$  above its origin, and farther upward, approximately midway between base and tip, it tapered into a delicate awl-like prolongation. Through retraction of contents from the attenuated distal part, and deposition of a cross-wall at the basal constriction (FIG. 2, *J, b*), a terminally appendaged conidium came into being at the tip of a short tapering sterigma. On exposure to moderately dry air the empty appendage soon shriveled, much like the similar appendages of various other zoöpagaceous forms (FIG. 2, *K, a-v*). As a general rule the cylindrical or somewhat fusiform living cell of the conidium tapered less markedly toward the base than in *Acaulopage rhicnospora*, and accordingly was somewhat more blunt at the proximal end.

Sexual reproduction took place simultaneously with asexual reproduction. Zygospores were formed in branches (FIG. 2, *C, b; L; M; N; O, a-c; P; Q; R*), which when relatively short—between  $15\mu$  and  $25\mu$  in length—were usually a little wider throughout than the parent filament (FIG. 2, *O, a, c*). When the branches



were longer such widening was evident only in a terminal portion, often measuring about 15 to 25  $\mu$  in length. At a stage when differentiation with respect to width first became noticeable, a cross-wall was laid down well toward the proximal limit of the swollen part, and a process grew out, sometimes from a position immediately above the septum (FIG. 2, *L*), sometimes from a position a few microns farther toward the tip (FIG. 2, *M*). The process, apparently, would then arch backward somewhat after the manner of clamp-connections in the basidiomycetes, and effect a junction with the parent branch just below the septum (FIG. 2, *N*). Soon after anastomosis was accomplished, if not at an earlier stage, a second cross-wall would be laid down to delimit a proximal gametangium frequently only one-half or one-third as long as the distal gametangium cut off by the first cross-wall (FIG. 2, *O*, *a-c*). The young zygosporangium thereupon developed as a subspherical enlargement, most often midway between base and apex of the distal gametangium, and less frequently in close proximity to the conjugation-tube, whether at the base of the distal gametangium (FIG. 2, *C*, *b*) or at the distal end of the proximal gametangium (FIG. 2, *P*). Relatively wide spatial separation of conjugation-tube and zygosporangium resulted occasionally from development of the latter toward the tip of the distal gametangium (FIG. 2, *N*, *Q*, *R*).

Once the globose zygosporangium had attained definitive size it was delimited proximally and distally by septa laid down in approximately tangential planes. Its originally smooth enveloping membrane would ultimately collapse somewhat loosely about the bullate contours of the yellowish zygosporangium. At maturity the zygosporangium, like that of other Zoöpagaceae, revealed an internal organization more familiar in oöspores: the thick spore wall surrounding a parietal layer of granular protoplasm, within which a largish reserve globule and a smaller oblate ellipsoidal refringent body were to be distinguished (FIG. 2, *S*, *a-q*).

Although formation of sexual spores on slightly thickened branches is known also in *Zoöpage cladosperma* Drechsl. (3), lateral conjugation has not hitherto been observed in any other member of the Zoöpagaceae. Frequently, indeed, union of the adjacent gametangia is accomplished by the fungus after a manner hardly

familiar in any groups of cryptogams. For while the conjugation tube here is sometimes present as a commonplace short direct connection comparable to the lateral connections in species of *Spirogyra*, it more often takes a curiously circuitous course (FIG. 2, *O*, *c*; *Q*; *R*), winding about the parent branch in a complete turn, to give somewhat the appearance of a circular flange or collar. In most instances of such circumvolution the intricate parts are too badly obscured to permit their relationship to be made out with any clearness. This circumstance, together with the small dimensions of the apparatus generally, has made it difficult to determine whether the conjugation-tube may not in some cases originate from the proximal rather than from the distal gametangium, or, again, whether the tube may not result from apical fusion of two processes put forth separately by the two gametangia.

A term suggested in part by the frequent similarity of the conjugation-tube to a circular fastening, and in part by the development of this unusual structure on branches, may serve appropriately as specific name for the fungus.

### ***Acaulopage gomphoclada* sp. nov.**

Mycelium sparsum, parce ramosum; hyphis continuis, hyalinis, leniter flexuosis, .6–1.3  $\mu$  crassis, ad animalcula inhaerentibus, pelliculam cujusque capti perforantibus, haustorium intrudentibus quod protoplasma exhaurit; haustoriis pediculatis, pediculo saepius 1.5–3  $\mu$  longo, .6–1  $\mu$  crasso, abrupte latescente, apice semel vel ter repetite bifurco, ita 2–8 ramulos assumentes divaricatos 1.5–8  $\mu$  longos 1.2–1.8  $\mu$  crassos ferente. Conidia hyalina, erecta, ex sterigmatibus 1  $\mu$  altis oriunda, ex partibus duabus composita: parte supera vacua, 8–20  $\mu$  longa, circiter .5  $\mu$  crassa, vulgo plus minusve marcida vel collapsa; parte infera protoplasmatis repleta, cylindrata vel elongato-fusiformi. 11–22  $\mu$  longa, 1.3–1.8  $\mu$  crassa. Ramuli zygosporiferi vulgo 15–50 longi, 1.2–2  $\mu$  lati, quoque binas cellulas sexuales (gametangia) ferente, una terminali et saepius 12–20  $\mu$  longa, altera huic proxime posita et saepius 2–10  $\mu$  longa; tubulo conjugationis a latere excrescente, interdum circum ramulum voluto; zygosporangio plerumque ex cellula sexuali terminali orto, primum levi, sphaeroideo, 7–10  $\mu$  crasso, membrana hujus mox circum zygosporam laxe collapsa; zygospora flavida, globosa, verrucosa, saepius 6–9  $\mu$  crassa, maturitate membrana ejus .6–1.8  $\mu$  crassa, corpus protoplasmatis sphaerale 4.5–6  $\mu$  crassum circumdante.

Amoebas 10–40  $\mu$  latas capiens consumensque habitat in foliis putrescentibus *Poa pratensis* prope Beltsville, Maryland.

Mycelium sparse, sparingly branched; the vegetative hyphae continuous, hyaline, slightly flexuous, .6 to 1.3  $\mu$  wide, capturing minute



animals through adhesion, then penetrating the pellicle of each captive and intruding into it a haustorium to appropriate the protoplasmic contents; haustoria pedicellate, the pedicel usually  $1.5$  to  $3\ \mu$  wide and  $.6$  to  $1\ \mu$  thick, widening abruptly and bifurcating 1 to 3 times to terminate in 2 to 8 divergent assimilative branches  $1.5$  to  $8\ \mu$  long and  $1.2$  to  $1.8\ \mu$  wide. Conidia hyaline, erect, arising singly from sterigmata  $1\ \mu$  long, each spore consisting of 2 parts: a distal empty part, mostly 8 to  $20\ \mu$  long and about  $.5\ \mu$  wide, often present as a withered appendage; and a proximal part filled with protoplasm, cylindrical with somewhat tapering ends or elongate fusiform, measuring 11 to  $22\ \mu$  in length and  $1.3$  to  $1.8\ \mu$  in width. Paired sexual cells (gametangia) formed adjacent to each other by deposition of 2 septa in slightly widened lateral branches which often measure 15 to  $50\ \mu$  in length and  $1.2$  to  $2\ \mu$  in thickness—one of the cells, usually 12 to  $20\ \mu$  long, constituting the terminal segment of the branch; the other, in penultimate position, varying usually from 2 to  $10\ \mu$  in length. Conjugation always of lateral type, the tube sometimes short and direct, but more often somewhat circuitous in course and often rather closely enwrapping the lower portion of the distal cell and the upper portion of the proximal cell; zygosporangium most frequently formed about midway between base and tip of the distal cell, subspherical, commonly 7 to  $10\ \mu$  in diameter, at first smooth, its envelope later collapsing somewhat loosely about the zygospore; zygospore yellowish, subspherical, commonly 6 to  $9\ \mu$  in diameter, rather prominently verrucose, its wall  $.6$  to  $1.8\ \mu$  in thickness, surrounding a spherical protoplast usually  $4.5$  to  $6\ \mu$  in diameter.

Capturing and consuming amoebae 10 to  $40\ \mu$  wide it occurs in decaying leaves of *Poa pratensis* near Beltsville, Md.

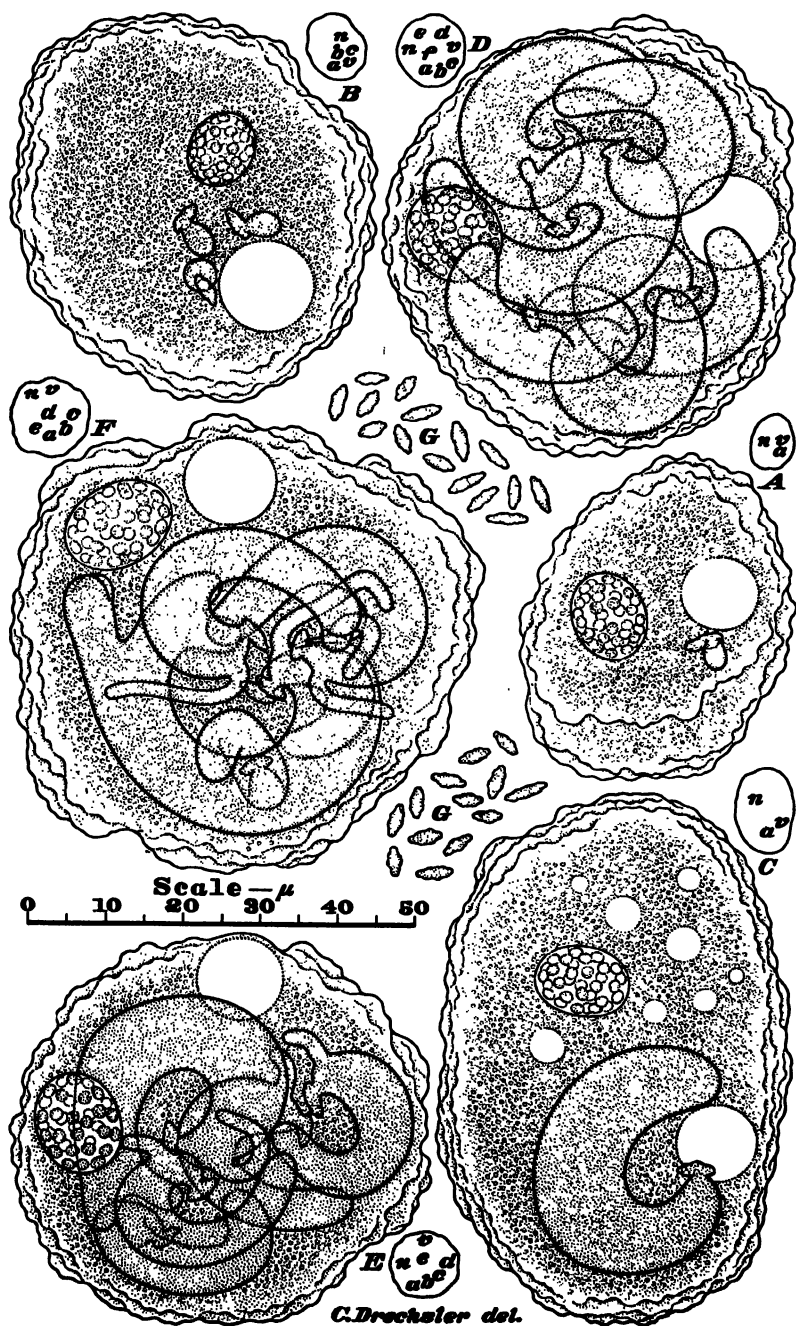
#### A ROBUST COCHLONEMA WITH SMALL VERRUCOSE CONIDIA

Several maize-meal-agar plate cultures which after being permeated with mycelium of *Pythium myriotylum* Drechsl. had received some addition of partly decayed bluegrass leaves removed on May 10, 1941, from a heap of old lawn clippings in Arlington, Va., showed 11 days later many scattered white tufts just visible to the naked eye under strong lateral illumination. Examined microscopically under low magnification the tufts were found to consist of conidial chains and of moniliform filaments destined for conversion into conidial chains. The chains and filaments varied in number mostly from 10 to 25, and arose, erect or ascending, in bush-like arrangement, from a common origin. In general ap-

pearance the tufts resembled more particularly the conidiiferous tufts of *Cochlonema symplocum* Drechsl. (6), and the constituent spores, as in that species, were markedly verrucose. Despite these similarities it was evident, even with low magnification, that the catenated spores here were shorter than the homologous bodies of either *C. symplocum* or *C. verrucosum* Drechsl. (1).

Consonant with expectations suggested by the resemblances, the tufts on being examined under high magnification were found to originate from spiral thalli lying within collapsed pellicles of amoebae whose protoplasm had either wholly or in large part disappeared. Many animals (FIG. 3, *A-F*) showing earlier stages of infection moved slowly about on the substratum, the smaller individuals measuring approximately  $35\ \mu$  across when drawn into a somewhat rounded form (FIG. 3, *A*), the larger ones of similar conformation (FIG. 3, *F*) attaining widths sometimes in excess of  $60\ \mu$ . Each infected specimen was enveloped in a very thin pellicle, delicately rippled all around except where a broad pseudopodium was actively being pushed forward. During the earlier stages of parasitic attack, before pathological changes became noticeable, the host protoplasm remained of a finely granular consistency, permitting easy recognition of the single nucleus (FIG. 3, *A*, *n-F*, *n*) and of the contractile vacuole (FIG. 3, *A*, *v-F*, *v*). Prolate ellipsoidal in shape and measuring 10 to  $14.5\ \mu$  and 8 to  $11\ \mu$  along its major and its minor axis respectively, the nucleus was distinguished especially by circulatory movement, close under its peripheral membrane, of about 30 to 35 slightly darker subspherical or oblate ellipsoidal bodies ranging between  $1\ \mu$  and  $2\ \mu$  in greatest dimension. The number of intranuclear bodies, as also their curious cyclosis, appeared to indicate close kinship of the host rhizopod with the *Amoeba* previously observed being utilized as prey by *Stylopaga cephalote* (4). While the animals attacked by the catenulate fungus were generally larger than those earlier found being captured by the capitate form, the difference in size was hardly sufficient to exclude the likelihood that the same protozoan species might have been concerned in both instances.

Infection is initiated through germination of a conidium (FIG. 3, *A*) or of several conidia (FIG. 3, *B*) unhappily ingested by the animal. The germ-tube put forth laterally or somewhat obliquely

FIG. 3. *Cochlonema euryblastum*.

from the spore is much stouter than the proximal portions of corresponding outgrowths in *Cochlonema symplocum* and *C. verrucosum*. During early stages of growth it widens rather markedly, though soon further elongation proceeds at a nearly uniform or gradually diminishing diameter (FIG. 3, *C, a*; *D, a-e*; *E, a, b*). As the young thallus lengthens it curves into a flat spiral. Branching for the most part takes place only after a complete turn has been described, and consequently often remains absent in thalli that have failed to attain the necessary proportions before their food supply has been exhausted. Whether a thallus concludes its development as a simple hypha, or as a branched hypha, depends, therefore, not only on the size of the animal host, but also on the measure in which other thalli participate in the expropriation of available protoplasmic materials. In instances where a host animal, even of relatively large size, is infected simultaneously by 5 or 6 conidia, so that its substance is rather equally divided between a corresponding number of thalli, all of the thalli may remain simple (FIG. 3, *D, a-f*), though in instances of multiple infection at separate times, where, for example, 1 or 2 of the thalli have begun development earlier than their fellows, the older individuals may become branched (FIG. 3, *E, e*; *F, d, e*). When an animal has been infected simultaneously by only 3 conidia, all of the resulting thalli may show branching (FIG. 4, *A*), though naturally more abundant ramification is afforded when only a single thallus is present (FIG. 4, *B-D*), and especially when a single thallus has developed in an animal of unusually large size (FIG. 4, *C, D*). The first bifurcation, as in *C. megalasomum* Drechsl. (5), usually takes place in the plane of the first spiral coil (FIG. 3, *E, d*; *F, e*. FIG. 4, *A, a, b*; *B*; *C*; *D*), though occasionally a primary dichotomy may be somewhat oblique to that plane (FIG. 4, *A, c*). Some dichotomies of the second order (FIG. 3, *F, e*) as well as some of the third (FIG. 4, *D*) and fourth (FIG. 4, *C*) orders, when such higher ramifications are present, also lie in the plane of the first spiral coil. The generally flat spiral conformation maintained up to the second dichotomies is rather little disturbed by irregularity of angular relationships in the second, third, and fourth bifurcations, since the branches resulting from these later ramifications are so markedly reduced in length and thickness that they constitute only a small portion of the whole thallus.

When the animal host has been disabled for further locomotion, owing to continuing loss of protoplasm, the thallus initiates asexual reproduction by putting forth a reproductive hypha from a position on its convex profile usually 3 to 10  $\mu$  from its origin (FIG. 3, *D, f*; *E, b-e*; *F, c, d*. FIG. 4, *A, a-c*; *B*). If the thallus is large a second reproductive hypha is put forth simultaneously from a position on the convex profile usually 3 to 10  $\mu$  beyond the first (FIG. 3, *F, e*. FIG. 4, *C, D*). After growing through the enveloping host pellicle each reproductive hypha branches several times (FIG. 4, *B*) to extend into the air eventually from 3 to 15 filaments beset with warty protuberances and noticeably constricted at close intervals. Once the individual filament has reached definitive length, it is converted into a chain of verrucose conidia through deposition of cross-walls at the constrictions (FIG. 3, *G*. FIG. 4, *C, E*). Development of the several spore chains that originate from the same reproductive hypha is in considerable measure successive, additional sporiferous branches being extended until the thallus has yielded up all its contents. Departure of protoplasm from a thallus is accompanied by progressive, conspicuous vacuolization (FIG. 4, *C; D; E*), but apparently does not entail deposition of retaining septa within the thallodic envelope.

The parasite is obviously referable to *Cochlonema*, and in that genus appears most closely akin to *C. verrucosum* and *C. symplecum*. From these species it differs markedly with respect to vegetative habit, especially when its thallus attains a size large enough to permit repeated branching. Since, however, the distinctly broad attachment between germinating conidium and thallus is observable much more often than abundant distal ramification, the fungus is described under an epithet compounded of two words meaning "wide" and "sprout," respectively.

### ***Cochlonema euryblastum* sp. nov.**

Hyphae assumentes protinus ex tubo germinationis saepius 1.5–2  $\mu$  crasso latescentes, hyalinae, continuae, 6–15  $\mu$  crassae, usque 125  $\mu$  longae, in spiram planam semel subinde paene bis volutae, nunc simplices nunc semel bifurcae nunc etiam bis vel ter vel quater crebro dichotomae, prope originem ex latere convexo unam hypham genitabilem vel quandoque duas hyphas genitabiles emittentes; hyphis genitabilibus 2–3.2  $\mu$  crassis, quoque sursum 3–15 ramos erectos vel ascendentes in aerem proferente qui in catenulas 30–80 conidiorum abeunt; conidiis hyalinis, verrucosis, plerumque 3–6  $\mu$  longis, 1.5–2  $\mu$  crassis.



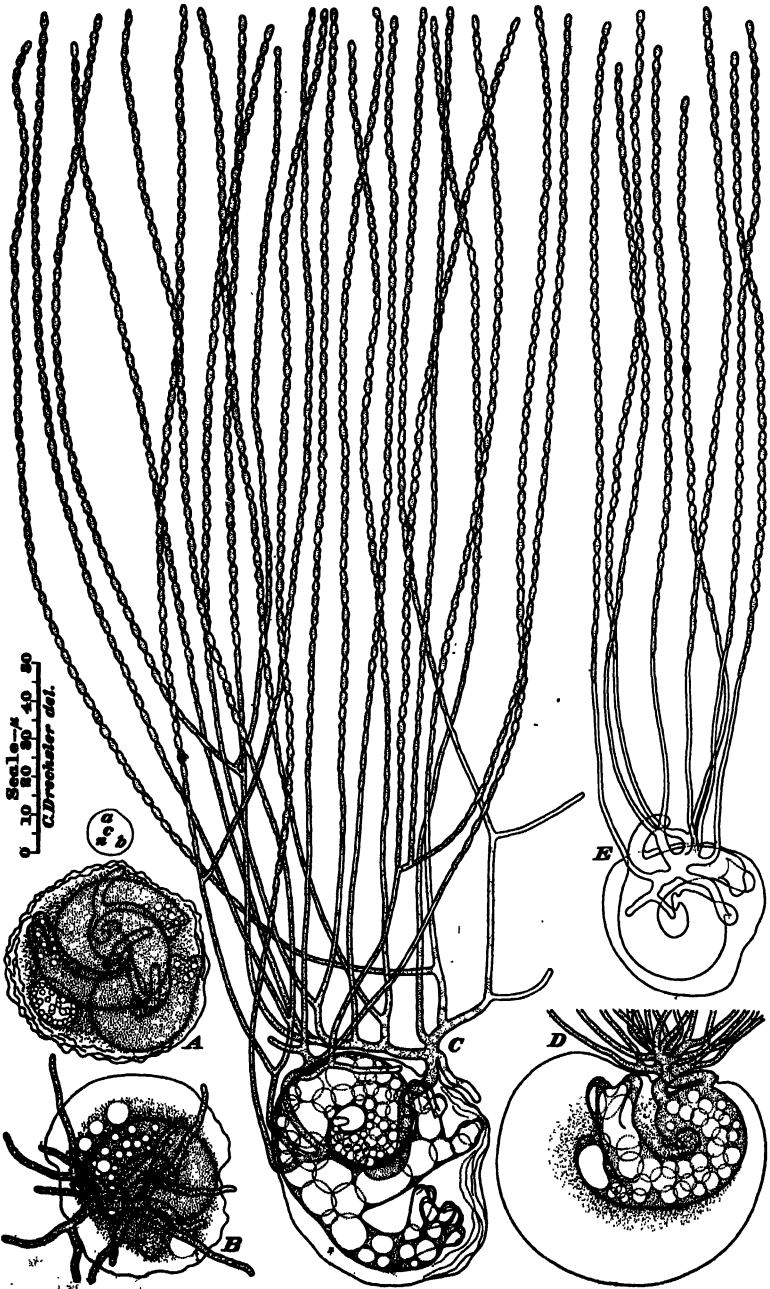


FIG. 4. *Cochlonema euryblastum*.

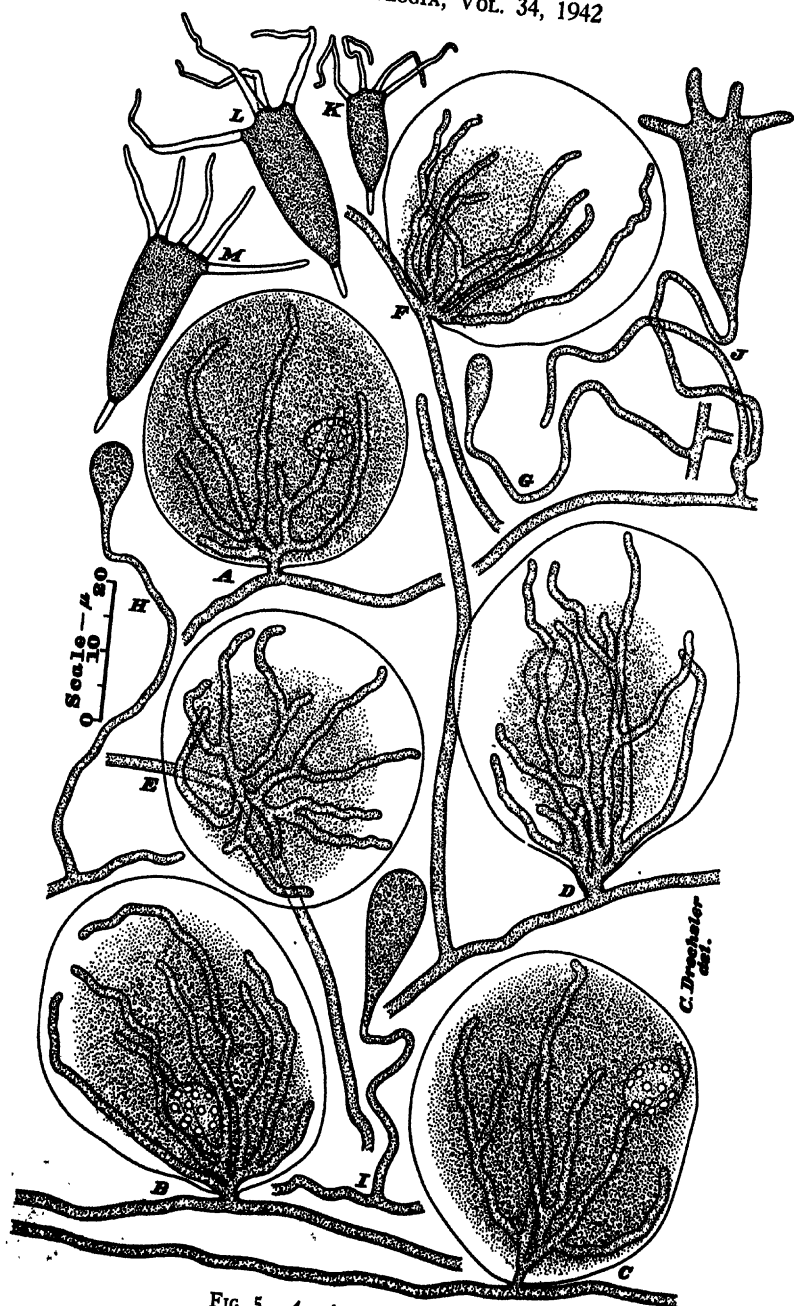
*Amoebas vulgo* 35–60  $\mu$  *latas encans habitat in foliis Poae pratensis putrescentibus in Arlington, Virginia.*

Assimilative hyphae widening out immediately from a germ-tube often 1.5 to 2  $\mu$  in thickness, hyaline, continuous, 6 to 15  $\mu$  in diameter, up to 125  $\mu$  in length, convolved in a flat spiral of one turn or occasionally of nearly two turns, often simple but sometimes once bifurcate and occasionally even further dichotomizing, though at shorter intervals, a second, third, or fourth time; the smaller specimens putting forth, from a position on the convex profile close to the proximal end, a single reproductive filament, the larger specimens putting forth 2 such filaments. Reproductive filaments 2 to 3.2  $\mu$  wide, each extending into the air 3 to 15 branches, which soon are converted in large part into chains of 30 to 80 conidia; conidia hyaline, warty, mostly 3 to 6  $\mu$  long and 1.5 to 2  $\mu$  wide.

Destroying amoebae commonly 35 to 60  $\mu$  wide it occurs in decaying leaves of *Poa pratensis* in Arlington, Va.

#### UTILIZATION BY ACAULOPAGE TETRACEROS OF THE AMOEBA CAPTURED BY ZOÖPAGE THAMNOSPIRA

In the original description of *Acaulopage tetraceros* little information was supplied relative to the morphology and specific identity of the animals found captured by the fungus. Cultures abundantly bestrewn with inversely lageniform and plurally appendaged conidia have come under observation from time to time in subsequent years, without, however, providing much additional knowledge of the prey; for usually when asexual reproduction had advanced far enough to invite attention, predaceous activity had virtually come to an end. Better success attended observations on an old *Pythium* culture to which had been added a few pinches of leaf mold collected in deciduous woods near Beltsville, Md., on January 7, 1941. Ten days after the decaying refuse was added predaceous activity appeared in two separate areas, and accompanying it, early development of conidia in sufficient quantity to permit identification of the two distinct zoöpagaceous forms concerned. In one of the tracts *Zoöpage thamnospira* Drechsl. (4) was readily recognized both from the morphology of its catenulate conidia, and from the gracefully coiled, thallus-like haustoria it extended into the captured amoebae. As in the cultures whereon the description of *Z. thamnospira* was based, the prey often measured about 40  $\mu$  across when

FIG. 5. *Acaulopage tetraceros*.

drawn into an approximately round shape, and contained a prolate ellipsoidal nucleus within which a dozen somewhat flattened orbicular bodies were distributed in positions close under the peripheral membrane. Amoebae entirely similar with respect to dimensions and nuclear organization (FIG. 5, *A-C*) were preyed upon also in the other tract of substratum, where, however, the protoplasmic materials were assimilated by means of more commonplace bush-like haustoria whose rangy branches showed no coiling and did not exceed the parent filaments in width (FIG. 5, *D-F*). Here and there the mycelial hyphae bore prostrate branches on whose erect tips were borne swollen bodies in various stages of development (FIG. 5, *G-J*) into conidia typical of *A. tetraceros* (FIG. 5, *K-M*). Accordingly the species of *Amoeba* habitually captured by *Z. thamnospira* is to be recognized also as prey of *A. tetraceros*. The animal further seems to be an intimate relative of the *Amoeba* parasitized by *Cochlonema euryblastum*, since its prolate elliptical nucleus, like that of the latter protozoan, shows orbicular bodies in gentle rotational movement close under the peripheral membrane. Yet as the rotating intranuclear bodies present here are conspicuously less numerous than those present in the host of *C. euryblastum*, the rhizopods are perhaps better considered to be merely congeneric rather than conspecific.

#### A VARIETY OF COCHLONEMA BACTROSPORUM WITH LONG CONIDIA

Seven weeks after some pinches of leaf mold collected near Haugen, Wis., in September 1939, had been added to an old *Pythium* culture on maize meal agar, the medium adjacent to one of the deposits showed a colony of *Heleopera sylvatica* Penard (7), numbering nearly a hundred individuals, being exterminated by a *Cochlonema* corresponding in nearly all respects to the description of *Cochlonema bactrosporum* (5). On close scrutiny it was found that the animals undergoing destruction were noticeably larger than those previously found parasitized in the cultures planted with decaying material from Beltsville, Md.; for they measured about 80  $\mu$  in average length, and about 50  $\mu$  in average width, as compared with corresponding values of 65  $\mu$  and 42  $\mu$ , respectively, derived from measurements of the earlier specimens. As far as

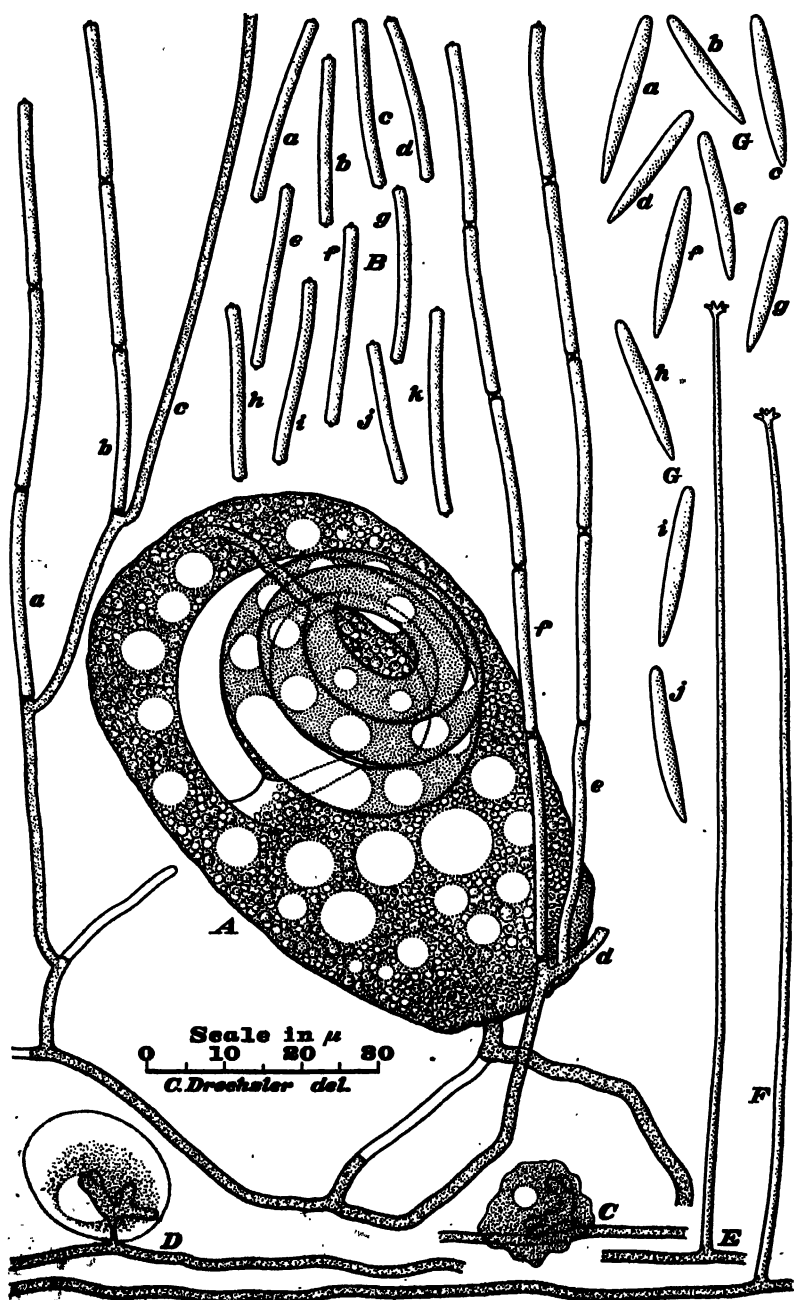


FIG. 6. A, B, *Cochlonema bactrosporum* var. *longius*; C-G, *Stylopaga cephalote*.

could be determined under very troublesome optical difficulties arising from the globulose texture of the degenerating host protoplasm, the grandiose helicoid thalli of the parasite (FIG. 6, *A*) resembled those previously encountered; and the resemblance extended evidently both to the reproductive filaments and to the aerial sporiferous branches while in immature condition. However segmentation of the aerial branches (FIG. 6, *A*, *a-f*) here resulted in conidia (FIG. 6, *B*, *a-k*) fully half again as long as those of the Maryland fungus. Since the material from either of the two sources showed only moderate variability in conidial length, the fungus from Wisconsin would seem to merit recognition as a distinct variety.

### ***Cochlonema bactrosporum* var. *longius* var. nov.**

Speciei typicae simile ad hypham alitam et hyphas fertiles; conidiis catenulatis, hyalinis, levibus, cylindratis, vulgo 20–31  $\mu$  longis, 1.6–1.9  $\mu$  crassis, utrimque in verruculam minutam abeuntibus.

*Heleoperam sylvaticam* formae grandis enecans habitat in humo silvestri prope Haugen, Wisconsin.

Similar to the type of the species with respect to vegetative hypha and conidiiferous filaments; conidia catenulate, hyaline, smooth, cylindrical, commonly 20 to 31  $\mu$  long, 1.6 to 1.9  $\mu$  wide, at each end terminating in a minute warty protuberance.

Destroying *Heleopera sylvatica* of a large type, it occurs in leaf mold near Haugen, Wis.

### SUPPLEMENTARY OBSERVATIONS ON STYLOPAGE CEPHALOTE

The same set of cultures that after being planted with partly decayed blue-grass leaves gave rise to *Cochlonema euryblastum* afforded development also of *Stylopage cephalote*. The latter fungus here subsisted through capture of an *Amoeba*, within whose prolate ellipsoidal nucleus about a dozen orbicular bodies appeared in gentle movement close under the peripheral membrane. With respect to number of intranuclear bodies, therefore, the animal agreed rather accurately with the *Amoeba* found subject to capture by both *Acaulopage tetraceros* and *Zoöpage thamnospira*.

*Stylopage cephalote* also developed rather abundantly in several maize-meal-agar plate cultures that had been planted with a few pinches of leaf mold from a collection of this material made near Charleston, S. C., in February, 1941. At the time observations

were begun the fungus had nearly concluded its vegetative growth. Only a few small amoebae were found adhering to the hyphae in newly captured condition (FIG. 6, *D*, *C*); the captives measuring about  $15\ \mu$  across when drawn into an approximately round shape, and revealing no nucleus in their turbid protoplasm. Remnants of pellicles more capacious than any that could have been left by such small animals were found attached here and there, indicating that larger prey may previously have been exterminated in furnishing a richer supply of nourishment. Many of the conidiophores arising from the predaceous filaments showed dimensions in tolerable agreement with the original description of the species (4); though others, again, gave measurements for height in excess of  $120\ \mu$  or  $130\ \mu$  (FIG. 6, *E*, *F*), and measurements for subterminal width as small as  $.6\ \mu$  or  $.8\ \mu$ . The conidia (FIG. 6, *G*, *a-j*) produced on these taller and more slender supporting hyphae showed no concomitant departure in morphology.

DIVISION OF FRUIT AND VEGETABLE CROPS AND DISEASES,  
BUREAU OF PLANT INDUSTRY,  
U. S. HORTICULTURAL STATION,  
BELTSVILLE, MARYLAND

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2. —. Some non-catenulate conidial Phycomycetes preying on terricolous Amoebae. *Mycologia* 27: 176-205. 1935.
3. —. New conidial Phycomycetes destructive to terricolous Amoebae. *Mycologia* 28: 363-389. 1936.
4. —. New Zoöpagaceae capturing and consuming soil Amoebae. *Mycologia* 30: 137-157. 1938.
5. —. A few new Zoöpagaceae destructive to large soil rhizopods. *Mycologia* 31: 128-153. 1939.
6. —. Four Phycomycetes destructive to nematodes and rhizopods. *Mycologia* 33: 248-269. 1941.
7. Penard, E. Faune rhizopodique du bassin du Léman. 1902.

#### EXPLANATION OF FIGURES

FIG. 1. *Acaulopage lasiospora*; drawn with the aid of a camera lucida to a uniform magnification;  $\times 1000$  throughout. *A*, Portion of hypha on which a relatively large amoeba has been captured by adhesion; at each of the three places of adhesion a haustorium is shown growing into the protoplasm; within the animal's body are visible also ten small contractile vacuoles

and three round bodies of uncertain function. *B*, Portion of mycelium with a captured amoeba; the latter being shown at an early stage of invasion by the haustorium. *C*, Portion of hypha on which two amoebae, *a* and *b*, have been captured by adhesion; within the sarcode of each animal portions of haustorial branches are faintly visible here and there. *D*, Portion of hypha with a captured amoeba within whose dense protoplasm portions of haustorial branches are faintly visible. *E*, Portion of hypha on which two small amoebae, *a* and *b*, have been captured; the smaller captive, *a*, has been depleted of protoplasm in sufficient measure to make the haustorium faintly visible throughout; in the slightly larger captive, *b*, depletion of protoplasm is further advanced, so that the haustorium has become clearly visible throughout. *F*, Portion of mycelium with two captured amoebae, *a* and *b*; each captive having been expropriated of its contents in such large measure that the haustorium has become clearly visible. *G*, *H*, *I*, Portions of mycelium, each with a captured amoeba; each captive has been almost wholly depleted of its protoplasm, so that the haustorium is clearly visible. *J-P*, Fertile branches, each bearing a growing conidium at its tip. *Q*, Portion of mycelium with a young conidium from which protuberances are being extended. *R*, Portion of mycelium with two conidia, *a* and *b*, whose protuberances are fully extended. *S*, Portion of hypha with a conidium whose fully extended and evacuated protuberances are arranged asymmetrically relative to the conidial axis. *T*, Mature conidium shown attached to a supporting branch from which the protoplasmic contents have been mostly withdrawn. *U*, Mature or nearly mature conidium attached to a branch that is still filled with protoplasm. *V*, Mature conidia, *a-g*, showing variations in size and shape of living cell, as well as in number, dimensions, and distribution of the empty appendages.

FIG. 2. *Acaulopage gomphoclada*; drawn with the aid of a camera lucida to a uniform magnification;  $\times 1000$ , except for supplementary drawings (each surrounded by a dotted line) showing details of conjugation in *N*, *O*, *R*, which are reproduced at a magnification of about 2000 diameters. *A*, *B*, Portions of mycelium, each with a captured amoeba into which a haustorium has been intruded; *n*, nucleus of animal; *v*, contractile vacuole. *C*, Portion of hypha which besides intruding a haustorium into the captured amoeba *a*, has given rise to a sexual branch, *b*, showing development of a nearly full-grown zygosporangium; *n*, nucleus of captured amoeba; *v*, contractile vacuole. *D*, Portion of mycelium with a captured amoeba whose contents have been largely assimilated by means of a single haustorium; *n*, nucleus of amoeba; *v*, contractile vacuole. *E*, Portion of mycelium from which two haustoria have been intruded into a captured amoeba, *a*, while a single haustorium has been intruded into a second amoeba, *b*; *n*, nucleus of each amoeba; *v*, contractile vacuole of each amoeba. *F*, Portion of mycelium from which a haustorium has been intruded into a captured amoeba. *G*, Terminal portion of a mycelial filament, showing two conidia, *a* and *b*, in early stages of development. *H*, *I*, Portions of mycelial hyphae, each showing an early stage in development of a conidium. *J*, Portion of mycelium showing one conidium, *a*, in an advanced stage of development, and another, *b*, in mature condition. *K*, Mature conidia, *a-v*, showing variations in the dimensions both of the living cell and of the empty appendage. *L*, *M*, Portions of mycelial hyphae,



each bearing a sexual reproductive branch in an early stage of development. *N*, Portion of hypha bearing a sexual branch with a conjugation-tube and a young zygosporangium. *O*, Portion of hypha bearing three sexual branches, *a*, *b*, *c*, each showing a conjugation-tube and a young zygosporangium. *P*, *Q*, *R*, Portions of mycelial hyphae, each bearing a sexual branch with a half-grown zygosporangium. *S*, Mature zygosporangia—some of them, *a-e*, shown with empty attachments; the others, *f-q*, shown without empty parts.

FIG. 3. *Cochlonema euryblastum*; drawn to a uniform magnification with the aid of a camera lucida;  $\times 1000$  throughout. *A*, Small specimen of the susceptible *Amoeba*, within which a single conidium, *a*, has begun to germinate; *n*, nucleus of host animal; *v*, contractile vacuole. *B*, Medium-sized specimen of the susceptible *Amoeba*, within which three conidia, *a*, *b*, *c*, have begun to germinate; *n*, nucleus of host animal; *v*, contractile vacuole. *C*, Rather large specimen of host *Amoeba* containing a single growing thallus, *a*; *n*, nucleus of host animal; *v*, contractile vacuole. *D*, Large specimen of host *Amoeba* containing six thalli, *a-f*, one of which, *f*, has begun putting forth a reproductive hypha; *n*, host nucleus; *v*, contractile vacuole. *E*, Fairly large specimen of host *Amoeba* containing five thalli, *a-e*, of which four, *b-e*, have each begun to put forth a reproductive hypha; *n*, host nucleus; *v*, contractile vacuole. *F*, Large specimen of host *Amoeba* containing five thalli, *a-e*, two of which, *c*, *d*, are each putting forth a single reproductive hypha, while another, *e*, of greater size, is putting forth two reproductive hyphae; *n*, host nucleus; *v*, contractile vacuole. *G*, Random assortment of conidia, showing variations in size, shape and sculpturing.

FIG. 4. *Cochlonema euryblastum*; drawn to a uniform magnification with the aid of a camera lucida;  $\times 500$  throughout. *A*, Specimen of host *Amoeba*, within which three thalli, *a*, *b*, *c*, have developed; each thallus shows a single dichotomy, and each has begun to put forth a single reproductive hypha; *n*, host nucleus. *B*, Specimen of host *Amoeba* whose protoplasmic contents have been assimilated almost entirely in the development of the distally bifurcate thallus, which near its proximal end has put forth a reproductive hypha that has produced several branches destined to grow into sporiferous aerial filaments. *C*, Collapsed pellicle of a parasitized *Amoeba*, within which a large thallus with four successive bifurcations has developed; the thallus, though not yet wholly depleted of contents, has put forth two reproductive hyphae, which together have given rise to three conidiiferous hyphae and twenty chains of conidia. *D*, Specimen of host *Amoeba* containing a thallus with three successive bifurcations; at its proximal end the thallus has put forth two reproductive hyphae that have branched copiously in giving rise to aerial conidiiferous hyphae whereof only the basal portions are shown. *E*, Empty pellicle surrounding membranous envelope of twice bifurcate thallus, which at its proximal end has put forth a single reproductive filament that has branched in giving rise to eight chains of conidia.

FIG. 5. *Acaulopage tetraceros*; drawn with the aid of a camera lucida to a uniform magnification;  $\times 1000$  throughout. *A*, *B*, *C*, Portions of hyphae with captured specimens of *Amoeba* sp., into which rangy arbuscular systems have been extended; each captive reveals a nucleus of approximately normal structure. *D*, *E*, *F*, Portions of hyphae with captured specimens of *Amoeba* sp.; the captives have lost nearly all their protoplasmic contents, and their

nuclei are no longer clearly recognizable. *G, H, I, J*, Creeping mycelial branches on each of which a conidium is being formed terminally. *K, L, M*, Mature conidia.

FIG. 6. Drawn with the aid of a camera lucida to a uniform magnification;  $\times 1000$  throughout.

*A, B, Cochlonema bactrosporum* var. *longius*: *A*, Specimen of *Heleopera sylvatica* containing a helicoid thallus of the parasite; from its proximal end the thallus has put forth a reproductive hypha, which on emerging from the mouth of the animal host has sent a few short branches into the substratum and given rise to two main branches; from one of these main branches two conidial chains *a, b*, and a young sporiferous hypha, *c*, have been extended, while the other main branch has given rise to three chains of conidia, of which two, *e* and *f*, are still intact, whereas the third is represented only by a sterile basal support *d*. (Owing to lack of space only proximal portions of the sporiferous hypha and of the four conidial chains are shown.) *B*, Random assortment of conidia, *a-h*, showing variations in length.

*C-G, Stylopage cephalote* from a culture planted with leaf mold collected in South Carolina: *C*, Portion of hypha from which a pedicellate haustorium has been intruded into a small amoeba captured through adhesion; though the captive is still alive, as is evident from the normal functioning of its contractile vacuole, no nucleus is visible in the turbid protoplasm. *D*, Portion of hypha from which a haustorium has been intruded into a captured amoeba; as the protoplasm of the captive has been very largely assimilated, the delicate pellicle has become flattened out so as to show a smooth outer contour. *E, F*, Portions of prostrate hyphae from which unusually tall slender conidiophores have arisen. *G*, Random assortment of conidia, *a-j*, showing usual variations in size and shape.

# PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXXVI. A NEW SPECIES AND GENUS

FRED J. SEAVER

(WITH 1 FIGURE)

In 1934 (*Mycologia* 26: 291.) Dr. S. M. Zeller described as new a fungus on the leaves of *Gaultheria Shallon* Pursh, and recorded it under the name *Dermatea brunneo-pruinosa*. The writer has never been able to determine why it should have been placed in that genus since it has none of the characters of *Dermatea*, as ordinarily understood. Zeller called attention to the fact that this fungus occurred on spots associated with *Pestalotia gibbosa* Hark., and that the two might be organically connected.

Recently (*Mycologia* 34: 180.) Dr. Lee Bonar of California has established the connection suggested by Zeller, proving by culture that the ascospores of Zeller's proposed species on germination produce the conidial or *Pestalotia* stage.

This is especially interesting to the writer since in 1928 a large collection of leaves of *Rhododendron maximum* L. was received from Dr. F. A. Wolf of North Carolina showing diseased spots bearing a *Pestalotia* stage and an apothecial stage so similar to that described by Zeller that they were at first thought to be identical. While the connection between the *Pestalotia* and the associated ascomycete on *Rhododendron* has not been proven, it is so similar to the one described by Zeller that we assume the connection to exist. Since the conidial stages of the two fungi appear to be distinct we for the present assume that the perfect stages are also distinct.

Much confusion has arisen through the fact that J. B. Ellis distributed this species in *Fungi Columbiani* 331 as *Dermatea lobata* Ellis, and this was later referred to *Lachnella rufo-olivacea* (Alb. & Schw.) Sacc. While there is an external resemblance, the species differs widely in habitat and in its much larger spores as well as in its conidial association and probable connections.

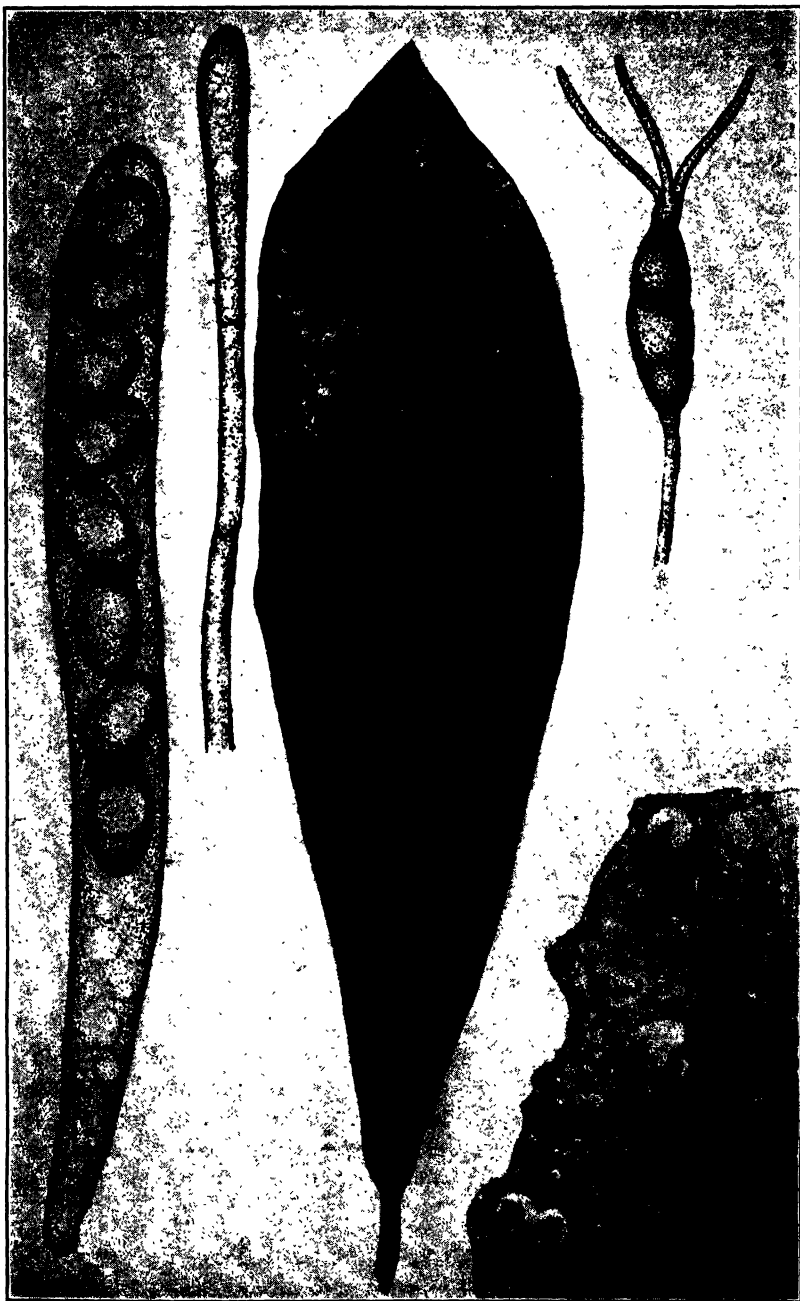


FIG. 1. *Pestalopezia Rhododendri*.

Since the species described by Zeller does not seem to fit well in the genus *Dermatca* and following the tendency to segregate genera on the basis of their conidial stages where these are known, the writer ventures to propose a new genus, combining the two names *Pestalotia* and *Peziza*. The form on *Rhododendron* is also recorded as a new species, but with the feeling that it may later be found to be identical with the form on *Gaultheria*. The following name is proposed for those species of cup-fungi which have a *Pestalotia* as their conidial stage.

***Pestalopezia* gen. nov.**

Apothecia superficial, sessile or subsessile, at first subglobose becoming expanded and subdiscoid, externally pruinose or tomentose, light colored; hymenium becoming nearly plane, dark colored, almost black; asci 8-spored, subcylindric paraphyses filiform and rather strongly enlarged with a *Pestalotia* as its conidial stage.

Apotheciis superficialibus, sessilibus vel subsessilibus, primo subglobosis dein suborbicularibus, extus pruinosis vel tomentosis; hymenio subatro; ascis subcylindraceis, 8-sporis; sporis ellipsoideis hyalinis; paraphysibus clavulatis, dilute fuligineis.

Type species: *Dermatca brunneo-pruinosa* Zeller, which would become ***Pestalopezia brunneo-pruinosa*** (Zeller) Seaver, comb. nov.

***Pestalopezia Rhododendri* sp. nov.**

Apothecia sparingly scattered near the center of circular or sub-circular dead spots apparently caused by the conidial or associated stage of the fungus *Pestalotia*, the spots becoming brown and bordered with concentric rings of variegated colors from red to brownish apothecia not exceeding 1 mm. in diameter, appearing as minute light colored balls, gradually expanding and exposing the dark colored discs; asci subcylindric to clavate, tapering into a short stem-like base, reaching a length of  $150\ \mu$  and a diameter of  $14\ \mu$ , 8-spored; spores 1-seriate, ellipsoid hyaline  $8 \times 16\ \mu$ ; paraphyses slightly enlarged above pale brown, reaching a diameter of  $6\ \mu$  at their apices.

Associated with what appears to be the *Pestalotia* stage, the spores with 3 brown cells  $10 \times 20\ \mu$  exclusive of the basal cell and bearing three appendages at the opposite end.

Apotheciis sparsis in maculis orbicularibus dispositis cum *Pestalotia* sp., epiphyllis, vix 1 mm. diam. extus pallidis, pruinosis, sessilis; hymenio sordide nigro; ascis subcylindraccis vel clavatis; sporis 8, ellipsoideis, hyalinis,  $8 \times 16 \mu$ ; paraphysibus dilute brunneis,  $6 \mu$  diam.

*Pestalotia* sp. Sporis brunneis, biseptatis  $10 \times 20 \mu$  ciliis in vertice tribus; pedicello hyalino.

On dead spots on leaves of *Rhododendron maximum* L., Pineola, North Carolina, July, 1938.

#### EXPLANATION OF FIGURE

Center, photograph of leaf of *Rhododendron maximum* L. infected with *Pestalotia* sp. and the apothecia of *Pestalopezia Rhododendri*. Lower right corner, photograph of several apothecia much enlarged. Left, an ascus and paraphysis much enlarged. Upper right corner, one spore of the *Pestalotia* associate.

# CONJUGATE NUCLEAR DIVISION IN THE FUNGI

B. O. DODGE

(WITH 2 FIGURES)

The term conjugate division has long been used to indicate that type of simultaneous division just preceding spore formation in sori of the rusts. Conjugate division also occurs in crozier formation in ascomycetes and in clamp connections of the hymenomycetes. The essential idea is that the spindles of the two nuclei lie more or less parallel and that septa cut across the spindles. One can not very well attribute a sex function to it in one instance and some other function when the occasion demands it. Whether or not the two nuclei so dividing are unlike genetically, or come from the same source or race has not been taken into consideration.

The mycelium of a homothallic mushroom is said to arise typically from a single spore with a single haploid nucleus. The germ tubes and even the earlier cells in the mycelium may be multinucleate. At a certain stage of maturity in some forms such as *Corticium coronilla*, a dicaryotic phase is established and clamps are regularly formed thereafter. Certainly in such forms the nuclei fusing in the basidium are alike genetically. No segregation occurs giving two kinds of spores so far as sex reactions are concerned. In such forms then the two nuclei dividing conjugately are the direct descendants through equational divisions from a single haploid nucleus.

We see so often in print statements that the binucleate or dicaryophytic stage of the rusts is maintained through conjugate nuclear division. The writer has never seen published any adequate evidence in support of such a statement. No doubt the nuclei of the "runner" cells do divide simultaneously, and no doubt the two nuclei of the pairs in the dicaryons in heterothallic species are direct descendants from two different sources or races. They are of opposite sex in their reactions. To say that the two nuclei in the rust

dicaryon divide conjugately and that septa are laid down across the spindles thus delimiting binucleate cells is going beyond what is so far known as a fact.

This whole question of the use of the term conjugate nuclear division is being tied up with the misuse of the term diploid. In certain basidiomycetes, such as *Coniophora cerebella*, there may be several clamp connections developed at each septum. A preparation sent to the writer by Dr. C. W. Emmons, shows plainly several pairs of "conjugate nuclei" in each cell. If a dicaryotic mycelium with one clamp at each septum is "diploid" a mycelium with two clamps at each septum, a tetracaryon, 4-nucleate cells, would be "tetraploid." The *Coniophora* mycelium would be "polyploid."

We are told that in those ascomycetes like *Neurospora* where the mycelial cells are multinucleate, the divisions are merely simultaneous and not conjugate at all. In those facultatively heterothallic species like *N. tetrasperma* and *Gelasinospora tetrasperma* the hyphal cells normally contain two kinds of nuclei as to their sex reactions. In these forms it is not unusual, just as has been reported for certain rusts, to find that nuclei of only one sex are cut off in certain branches. This is proof enough, one could say, that the two kinds of nuclei are not conjugate. This view then would provide a way of avoiding being compelled to call cells of *Neurospora* and *Gelasinospora*, "diploid" because they have two different kinds of nuclei, or worse still of calling them "polyploid" because each cell contains many sets of chromosomes. If conjugate division is the *sine qua non* for the new kind of "diploid," let us look at nuclear behavior in the ascus of *Gelasinospora tetrasperma*. Figure 1 adapted from illustrations published in Cytologia 1937, needs little comment. Suppose we try to apply the term "diploid" as it has been newly defined. The ascus, figure 1, *A*, with its fusion nucleus all agree is diploid. The first division occurs, leaving two haploid conjugate nuclei in the ascus. Since these nuclei differ genetically and are of opposite sex, and the cell contains two sets of chromosomes, the ascus is still "diploid" according to the new idea. Conjugate nuclear division occurs, ascus *B*, one pair of conjugate nuclei (two nuclei of opposite sex) moves to each end, ascus *C*. If one pair of conjugate nuclei makes a cell "diploid" two pairs make it "tetraploid." Perfect conjugate division occurs in both



pairs ending in a cell containing four pairs of conjugate nuclei. The ascus becomes "octoploid," ascus *E*. Here we have an exact replica of what occurs at the base of the aeciospore chain: conjugate division with a cutting across of the pairs of spindles by spore walls leaving a pair of conjugate nuclei in each spore, asci *F* and *G*. These spores are "diploid," but only for a few hours at most, because with another perfect conjugate division, *J*, *K*, each spore is

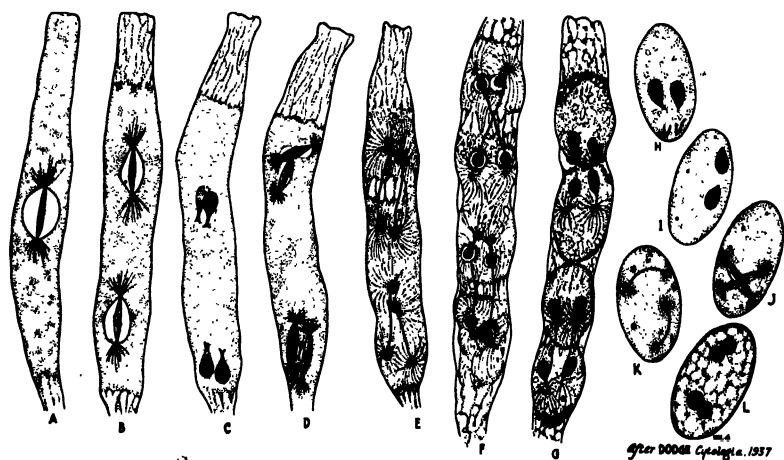


FIG. 1. A-L. Sketches showing nuclear behavior including conjugate nuclear division in connection with spore formation in *Gelasinospora tetrasperma*.

provided with four nuclei, *L*, four sets of chromosomes, so it must be "tetraploid." At spore germination the germ tubes and mycelial cells are given several nuclei each and so must be "polyploid!"

In one respect *Neurospora tetrasperma* gives us a more perfect conjugate division of the first pair of conjugate nuclei reorganized after reduction, figure 2, 4, because the two spindles most commonly lie close together and parallel. That all these divisions normally must be conjugate and thus serve a very definite end, is evident if we look at ascus 14, which shows that if the spindles diverge widely two small spores which have only a single haploid nucleus each are cut out. Some spores are therefore haploid, and according to the new system, others "diploid," depending on how many sets of chromosomes the cell contains, this regardless of

whether the sets are included within a single membrane, or each set is in its own membrane.

How much simpler and clear it would all be to use the old well tried terms uninucleate, binucleate or dicaryotic, multinucleate, haploid, diploid, polyploid in the usual way and avoid utter confusion.

The fusion nucleus in the ascus is the zygote, the ascus being at this time diploid and a mother cell, it may also be called a zygote. The cells from which the ascus arises, cells of the ascogenous hyphae, are not zygotes. No other cells in the ascocarp or in the mycelium

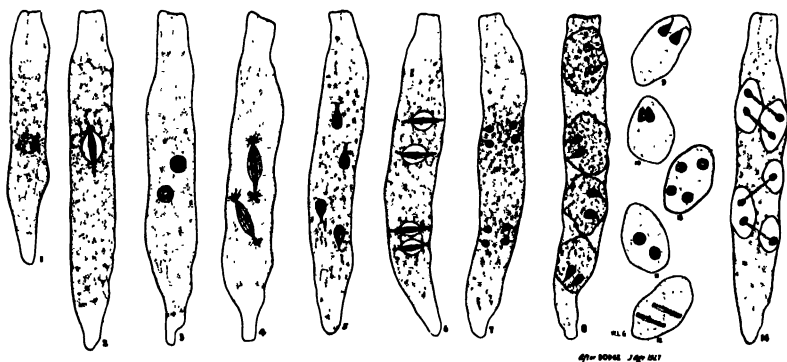


FIG. 2. 1-14. Diagrams showing spindle orientation in conjugate nuclear division in *Neurospora tetrasperma*. In ascus 14 the dotted lines connecting the nuclei in the spores simply indicate the original location of the spindles. See text for fuller description.

are zygotes. Their nuclei are not zygotes, therefore such cells and nuclei can not be *heterozygotes* or *heterozygous*. The fusion nucleus in the basidium of basidiomycetes is the zygote and we may say the mature basidial cell is a zygote cell. The cells from which basidia arise are not zygotes, their nuclei are haploid and not zygotes. The cells of the dicaryon are not zygotes. Therefore, such cells and such nuclei could not be heterozygotes or heterozygous, but the cells could very well be *heterocaryotic*.

The writer has pointed out on a number of occasions, particularly in a paper, now a long time in press, that the dicaryotic phase of the basidiomycetes is a highly interesting and important one, in that it gives us the opportunity in many cases to study the effects of genes as they are included in pairs of haploid nuclei, dicaryons, as contrasted with the effects of a single set of the same genes working

alone in uninucleate cells. In forms with multinucleate cells, such as *Neurospora* we may study homocaryotic as contrasted with heterocaryotic conditions. Growth from uninucleate microconidia and tertiary conidia is very slow at first as compared with growth from the large multinucleate conidia or hyphal fragments which is very rapid. Dickson reported in 1934 that dicaryons of his *Coprinus* always grew faster than did the individual components grown alone. The writer has, in a recent paper, shown that different sets of genes included in different nuclear membranes but in the same cytoplasm may act independently or in a complementary or supplementary way. It was assumed as an hypothesis that growth substances synthesized by one of the components supplement the growth substances synthesized by the other component, or components, to provide an optimum or full quota of growth substances necessary for vigorous growth. It was pointed out that heterocaryotic vigor, true hybrid vigor and individual vigor may be due to exactly the same or similar causes. Nevertheless they should be distinguished. True hybrid vigor, positive heterosis, is manifested in connection with structures in which the nuclei are diploid, that is, each nucleus contains a double number of chromosomes, two different sets. Heterocaryotic vigor, effects of heterocaryosis, if operating, is manifested in structures containing two or more kinds of haploid nuclei; dicaryotic vigor would express very beautifully the situation where the inclusion of two haploid components in a common cytoplasm, each synthesizing growth substances supplementing those made by the other component, results in the development of a mycelium which is more vigorous in growth than that of either of the haploid components.

By actually crossing a dwarf race with a more normal race, new haploid progeny were obtained. Through a fortuitous recombination of genes, these new homocaryotic races were able to synthesize a full quota of the necessary growth substances and so grew just as vigorously alone as did the heterocaryotic mycelium made up of the two original haploid parent components. It must be obvious to all that to call these new haploid progeny hybrids which showed hybrid vigor would be very incorrect and misleading.

If we introduce nuclei that carry genes for conidia into cells of a non-conidial race or vice-versa and find that the heterocaryotic

mycelium produces conidia, the question as to whether we may say that the factors for conidia are dominant to their alleles may be a purely academic one. On first consideration it would seem of little consequence. The important thing is to learn that the genes do act so independently. Many conidia are actually cut off the nuclei of which do not carry the genes favoring formation of conidia. Unpublished results of experiments on this problem have convinced the writer that we should still continue to say that Mendelian dominance is expressed in connection with diploid structures, yet be alert to discover just how and why heterocaryotic growth is determined by the nature of the genes included in the various nuclear components acting independently or coöperatively. Heterocaryotic vigor represents one of the effects obtained when two or more nuclei which differ genetically are working in a common cytoplasm. The effects of heterocaryosis may include color formation, change in rate and type of growth and the production of conidia or other morphological entities. They may be positive, resulting in heterocaryotic vigor, intensification of color, increased formation of conidia and other structures; or they may be negative, resulting in partial or complete inhibition of one or more of the characters of the component strains. Heterocaryotic vigor differs from heterosis in that the latter always implies a preceding fusion of unlike nuclei.

NEW YORK BOTANICAL GARDEN

# INDIAN AND BURMAN SPECIES OF THE GENERA PESTALOTIA AND MONOCHAETIA

B. B. MUNDKUR AND K. F. KHESWALLA

The specimens of *Pestalotia* and *Monochaetia* on which this report is based were collected by E. J. Butler and his colleagues over a period of nearly twenty years in different parts of India and Burma. Six of these have been recorded by Butler and Bisby (1931) and three by Mundkur (1938) bringing the total for India and Burma to nine species. A study of the collections, some of which are not in a first class condition, has shown that the total number of species of *Pestalotia* occurring in these two countries is twenty-nine and there are two imperfectly determined specimens. Two species of *Monochaetia* are recorded here for the first time.

Two hundred and seventy-one species of *Pestalotia* are recorded in Saccardo's "Sylloge Fungorum" and the taxonomy of some of them has been investigated by Klebahn (1914) and Guba (1929, 1932). A monographic treatment of the genus based on an examination of the *types* seems desirable and until such a study is made, confusion in the classification of this genus with very imperfect type descriptions will continue to exist.

In the differentiation of species of both the genera much emphasis is laid on the characters of the conidia and the fruiting structures; there has been, however, considerable controversy with regard to the latter. Free spores on mycelial threads, spores in open acervuli, spores in acervuli covered by a pseudo-parenchyma (pseudopycnidium) and spores in true pycnidia have been reported. That true pycnidia are formed in *P. palmarum* and *P. Guepini* is evident from the cultural work carried out by Archer (1926). It is therefore manifest that the fructification may be either an acervulus or a pycnidium in this genus.

The material available for study was very brittle and had to be softened before sections could be cut. For this purpose, it was placed in a mixture of equal parts of sixty-five per cent alcohol and

pure glycerine and placed in an oven at 60° C. for twenty-four hours. This treatment helped considerably in softening it.

PESTALOTIA de Notaris, Mem. R. Accad, Torino, p. 80

1. PESTALOTIA MANGIFERAE P. Henn. Ann. Mus. Congo Belge V. Fasc. II. 120. 1907; Sacc. Syll. Fung. 22: 1223. 1913.  
Syn. *P. funerea* Desm. forma *Mangiferae* Sacc. (Uppal, Patel & Kamat, 1935, p. 27.)  
*P. virgatula* Kleb. Mykol. Zbl. 4: 13. 1914 (Guba, 1929, p. 222; Mundkur, 1938, p. 40.)  
*P. pauciseta* Sydow (nec. Saccardo) Ann. Myc. 15: 262. 1917.

On living leaves of *Mangifera indica* L. Poona, 22-8-1903 (E. J. Butler); Dehra Dun, 16-12-1903 (E. J. B.); Pusa, 19-4-1904 (E. J. B.); Suri-Birbhum (Bengal), 30-12-1905 (S. K. Basu); Chittagong, 15-8-1908 (R. Sen); Port Blair (Andamans), 31-1-1927 (M. Mitra and M. Taslim); Sabour, 4-10-1937.

2. PESTALOTIA GOSSYPII Hori ex S. Thurudal, Jl. Pl. Prot. p. 27. 1917. (Tanaka, 1919, p. 154) Sacc. Syll. Fung. 25: 603. 1931.

On living leaves of *Gossypium* sp. Aligarh, 9-9-1908 (Parr).

3. PESTALOTIA LEPROLEGNA Speg. Ann. Mus. Nac. Buenos Aires 23: 119. (Guba, 1929, p. 216.) Sacc. Syll. Fung. 25: 1604. 1931. (Mundkur, 1938, p. 40.)

On living leaves of *Musa sapientum* L. Dhalghat, Chittagong, 7-12-1907 (R. Sen). Also reported from Bombay. Spegazzini's fungus was on the skins of mature fruits; the present collection is on leaves but agrees with the description of *P. leprolegna* given by Spegazzini (1912).

4. PESTALOTIA MENEZESIANA Bres. & Torrend, Broteria p. 142. 1909; Sacc. Syll. Fung. 22: 1223. 1913.

On living leaves of *Leea* sp. Sirsi, Bombay, October 1919 (L. J. Sedgwick).

5. *PESTALOTIA MALORUM* Elenkin & Chi, Z. Bolezni Rastenii p. 94. 1912; Sacc. Syll. Fung. 25: 605. 1931.

On living leaves of *Pyrus Malus* L. Maymyo, Burma, 18-1-1908 (E. J. B.).

6. *PESTALOTIA MICHENERI* Guba, Mycologia 24: 371. 1932.

On living leaves of *Araucaria* sp. Darjeeling, 27-8-1909 (Hafiz Khan).

7. *Pestalotia Taslimiana* sp. nov.

Acervuli, atri, minuti, plurimi, primo gregarii denique confluentes, subepidermales, erumpentes, foliis utrimque dispositi. Conidii fusiformia, erecta, apices versus fastigiata, 5-locellata,  $14.3-20.9 \times 4.5-6.6 \mu$ , ex brunneo subnigra; cellula medianae  $11.1-18.5 \times 3.7-7.7 \mu$  (med.  $14.8 \times 6.4 \mu$ ); cellula media  $3.7-5.5 \times 3.7-7.4 \mu$  (med.  $4.1 \times 6.4 \mu$ ) cellula terminalis longa setis 3 vel rarius 4,  $8-12 \mu$  longis, modice divergentibus, ornata; cellula basalis acuta, in rostellum caudatum extensa.

Hab. in *Calamo* sp. Chittagong or. 15-12-1907, Typus (No. 2250 ex Herb. Crypt. Ind. Orient.); Pusa, 24-8-1916 (M. Taslim).

Acervuli black, numerous, at first gregarious later coalescing, minute, sub-epidermal, erumpent, on both sides of the leaves. Conidia fusiform, erect, tapering at the ends, 5-celled,  $14.3-20.9 \times 4.5-6.6 \mu$ , median cell  $11.1-18.5 \times 3.7-7.7 \mu$  (mean  $14.8 \times 6.4 \mu$ ); middle cells  $3.7-5.5 \times 3.7-7.7 \mu$  (mean  $4.1 \times 6.4 \mu$ ) umber to dark brown; apical cell long, with 3 rarely 4 setae,  $8-12 \mu$  long, moderately divergent; basal cell acute with a caudate process.

On *Calamus* sp. Chittagong, 15-12-1907, Type (No. 2250 of Herb. Crypt. Ind. Orient.); deposited in Herb. Crypt. Ind. Orient., Herbarium.

This species differs from others reported on the order Palmae by its larger spores, characteristic basal cell with its caudate process, and in the fruiting structure being an acervulus.

8. *PESTALOTIA LONGI-ARISTATA* Maublanc, Bull. Soc. Myc. Fr.: 92. 1905; Sacc. Syll. Fung. 25: 603. 1931.

On living leaves of *Eriobotrya japonica* Lindl., Dehra Dun, 2-10-1905 (E. J. B.).

9. *PESTALOTIA ELASTICOLA* P. Henn. Hedwigia **48**: 16. 1909; Sacc. Syll. Fung. **25**: 603. 1931.

On living leaves of *Ficus elastica* Roxb. Badamtam (Darjeeling) 2-9-1909 (W. McRae); on leaves of *Artocarpus integer* (Thumb.) Merr. (= *A. integrifolia* L. f.) Pusa, 1916 (E. J. B.).

10. *PESTALOTIA VERSICOLOR* Speg. Michelia: 479. 1879; Sacc. Syll. Fung. **3**: 790. 1884. (Klebahn, 1914, p. 12; Guba, 1929, p. 222.)

On leaves of *Carissa* sp. Karwar, Oct. 1919 (L. J. Sedgwick).

11. *PESTALOTIA SAPOTAE* P. Henn. Hedwigia **48**: 17. 1909; Sacc. Syll. Fung. **25**: 606. 1931.

On mature fruits of *Achras Sapota* L. Kirkee, 22-1-1937. Hennings reported the fungus on leaves but the Kirkee specimen was on the skins of mature fruits placed in cold storage.

12. *PESTALOTIA PSIDII* Pat. in Pat. & Lagerh. Bull. Soc. Myc. Fr.: 232. 1895; Sacc. Syll. Fung. **14**: 1025. 1899. (Guba, 1932, p. 379; Mundkur, 1938, p. 40.)

On fruits of *Psidium guyana* L. Dharwar, October 1907 (det. Patouillard); Mandalay, July 1915 (F. J. F. Shaw).

13. *PESTALOTIA CLAVISPORA* Atk. Bull. Cornell Univ. p. 37. 1897; Sacc. Syll. Fung. **14**: 1028. 1899. (Guba, 1932, p. 363.)

On the upper surface of the living leaves of *Quercus incana* Roxb. Mussoorie, 9-9-1914 (P. C. Kar).

14. *PESTALOTIA MANGALORICA* Thüm. Rev. Myc. p. 37. 1880. Sacc. Syll. Fung. **3**: 790. 1884. (Butler & Bisby, 1931, p. 159.)

On living leaves of *Bridelia stipularis* Bl. (= *B. scandens* Willd.), North Kanara Dt., October 1919 (L. J. Sedgwick). The type of this species on *Bridelia scandens* Willd. collected by Keck



at Mangalore is not available in India. A specimen of *Pestalotia* on leaves of *Mallotus* sp. collected by T. F. Chipps at Penang (Malaya peninsula) on 3-8-1919 is the same species.

15. *Pestalotia Citri* sp. nov.

Acervuli minuti, punctiformis, atri, in magnis maculis pallidis marginibus prominentibus dispositi. Conidia 5-locellata; cellulae terminales hyalinae, fastigiatæ, fusiformis,  $10.1-19.3 \times 5.0-5.5 \mu$ ; cellulae media guttulate, fuscae vel olivaceae,  $6.8-14.3 \mu$  longae, septis haud constrictae; setae 3 vel 4,  $10-19.5 \mu$  longae, divergentes, haud ramosae.

Hab. in foliis vivis *Citri grandis* Osbeck (= *C. decumana* L. p.p.). Kirkee 11-8-1914 (H. M. Chibber), Typus, No. 2209 Herb. Crypt. Ind. Orient.

Acervuli minute dot-like, black, seated on large bleached spots with raised edges; conidia 5-celled, end cells hyaline, tapering,  $10.1-19.3 \times 5.0-5.5 \mu$ ; median cells guttulate, umber to olivaceous,  $6.8-14.3 \mu$  long; not constricted at septa; setae 3 to 4, each 10 to  $19.5 \mu$  long, divergent, unbranched.

On living leaves of *Citrus grandis* Osbeck (= *C. decumana* L. p.p.). Kirkee, 11-8-1914 (H. M. Chibber). Type No. 2209 of Herb. Crypt. Ind. Orient. Also deposited in the Herbarium of the Imperial Mycological Institute, Kew.

16. *PESTALOTIA BANKSIANA* Cava, Atti Ist. Bot. Univ. Pavia p. 435. 1888; Sacc. Syll. Fung. 10: 489. 1892.

On leaves of *Grevillea robusta* A. Cunn. Vayitri, Calicut, 9-9-1904 (E. J. B.).

17. *PESTALOTIA ALBO-MACULANS* P. Henn. Hedwigia 43: 94. 1904; Sacc. Syll. Fung. 18: 480. 1906.

On living leaves of *Flemmingia* sp. Ballahari, Kanrup, 29-7-1912 (M. Taslim).

18. *PESTALOTIA SUFFOCATA* Ellis & Ev. Jour. Myc. 2: 38. 1886; Sacc. Syll. Fung. 10: 485. 1892.

On stems of *Rosa* sp. Pusa, 11-6-1916 (R. Sen).

19. *PESTALOTIA GUEPINI* Desmaz. Ann. Sci. Nat. II. 13: 183. 1840; Sacc. Syll. Fung. 3: 794. 1884. (Klebahn, 1914, p. 7; Guba, 1929, p. 198.)

On living leaves of *Hevea* sp. Port Blair (Andaman Islands), Feb. 1927 (M. Mitra). The *Pestalotia* on *Hevea* sp. is considered by La Rue (1922) to be *P. Guepini* but Petch (1921) considers it to be *P. palmarum* Cooke. Placed in this species tentatively.

20. PESTALOTIA THEAE Sawada, Spec. Rep. Agr. Exp. Sta. Taiwan p. 113. 1915. (Tanaka, 1917, p. 171.) Sacc. Syll. Fung. 25: 607. 1931. (Butler, 1918, p. 451; Butler & Bisby, 1931, p. 159.)

On living leaves of *Camillia sinensis* L. Bisnath (Assam), 8-8-1898 (Watt); Darjeeling, 15-7-1909 (W. McRae); Wyanaad, Malabar, 18-11-1909 (W. McRae); Port Blair (Andamans) 7-2-1927 (M. Mitra and M. Taslim).

21. PESTALOTIA PAUCISETA Sacc. Ann. Myc. 12: 311. 1914; Sacc. Syll. Fung. 25: 608. 1931.

On living leaves of *Litchi chinensis* Sonner (= *Nephelium Litchi* Camb.). Pusa, 4-4-1907 (Inayat Khan).

22. PESTALOTIA MACROTRICHA Klebahn, Mykol. Zbl. p. 6. 1914; Sacc. Syll. Fung. 25: 601. 1931. (Guba, 1929, p. 214.)

On living leaves of *Rhododendron campanulatum* Don. Ranikhet (Kumaon), 2-5-1907 (E. J. Butler).

23. PESTALOTIA FUNEREA Desmaz. Ann. Sci. Nat. p. 335. 1843. (Klebahn, 1914, p. 5; Guba, 1929, p. 202; Sydow & Butler, 1916, p. 220; Butler & Bisby, 1931, p. 159.)

On living leaves of *Cunninghamia sinensis* R. Br. Dehra Dun, 8-4-1904 (E. J. B.); on leaves of *Cupressus sempervirens* L., South India (date of collection and name of collector not stated).

24. PESTALOTIA LEPIDOSPERMATIS P. Henn. Hedwigia 40: 355. 1901; Sacc. Syll. Fung. 18: 484. 1906.

On leaves, leaf-sheaths and also culms of *Fuirena* sp. Maymyo (Burma) 19-1-1908 (Inayat).

25. *Pestalotia pipericola* sp. nov.

*Pseudopycnidia* 40–137  $\mu$  diametro, globosa, numerosa, epiphylla, sparsa, primo subepidermalia, deinde per cutem erumpentia, maculis mortuis cinereis sine margine finito disposita. Conidia 5-cellulata, recta vel nonnihil curvata, media parte tumescentia, 16.6–25.9  $\mu$ ; cellulae medianae 3, ex nigro sub-brunneae, 11.1–18.5  $\times$  5.5–11.1  $\mu$ ; med. cellula 3.7–7.4  $\times$  3.5–15.5  $\mu$ ; pedicellus filiformis. Setae 3, raro 2, unaquaeque cum aliis angulo obtuso disposita.

Hab. in foliis *Piperi nigri* L. Wynaad, Malabar, 1909 (leg. W. McRae), No. 2244 (Typus).

*Pseudopycnidia* 40–137  $\mu$  in diameter, globose or subglobose, numerous, epiphyllous, scattered, at first subepidermal, later bursting through the epidermis, erumpent, seated on ashen grey dead areas without a definite margin. Conidia five-celled, straight or slightly curved, bulged in the middle, 16.6–25.9  $\mu$ ; median cells three, dark brown, 11.1–18.5  $\times$  5.5–11.1  $\mu$ ; middle cell 3.7–7.4  $\times$  3.5–11.5  $\mu$ ; pedicel filiform. Setae three, rarely two, at sub-obtuse angle to each other.

On leaves on *Piper nigrum* L. Wynaad, Malabar, 1909 (leg. W. McRae), No. 2244 (type).

Type deposited in the Herb. Crypt. Ind. Orient., New Delhi.

26. *PESTALOTIA PALMARUM* Cooke, *Grevillea* 3: 115. 1875; 4: 102. 1876; Sacc. Syll. Fung. 3: 796. 1884 (Klebahn, 1914, p. 9; Guba, 1929, p. 210; Butler & Bisby, 1931, p. 159).

Syn. *P. Phoenicis* Vize, *Grevillea* 4: 14. 1876. (Butler & Bisby, 1931, p. 159.)

*P. brevipes* Prillieux & Delacroix, Bull. Soc. Myc. Fr. p. 788. 1895 (non Cooke).

*P. palmicola* Sacc. & Sydow, in Sacc. Syll. Fung. 14: 1030. 1899.

*P. pinnarum* Butler, nomen nudum. (Uppal, Patel & Kamat, 1935, p. 28.)

On living leaves of the following hosts:

*Areca catechu* L. Chittagong, 19–12–1907 (R. Sen).

*Borassus flabellifer* L. Godagiri (Bengal), 31–8–1905; Suri Birbhum (Bengal), 30–12–1905 (Basu); Harpur (Bihar), 28–11–1921 (Taslim).

*Cocos nucifera* L. Tellicherry, 26-9-1904 (E. J. B.); Rangpur, 22-9-1908 (Hafiz Khan); Chaumuhani (Bengal) 6-12-1911 (E. J. B.); Port Blaid (Andaman Islands), 31-12-1927 (M. Taslim).

*Phoenix sylvestris* Roxb. Wasai (Bombay) 3-11-1902 (I. H. Burkill); Jalay (Bihar) Dec. 1915 (M. Taslim).

*Phocnix* sp. Pusa, 16-5-1905 (E. J. B.); Chittagong, 16-12-1925 (R. Sen). Palm, Dehra Dun, 1-7-1903 (E. J. B.).

## 27. *Pestalotia Lawsoniae* sp. nov.

Maculae numerosae superne, plerumque rotundae, aliquando in macular irregulares pallide brunneas aliquae coalescentes. Acervuli amphigeni, nigri, erumpentes, 54-96  $\mu$  diametro. Conidia fusiformia vel cymbiformia, 5-cellularia; tres medianae cellulae septo constrictae, cellulae brunneae 11.1-14.8  $\times$  3.7-7.5  $\mu$ , cellula media 3.7-5.5  $\times$  3.7-7.4  $\mu$ . Setae 2, 8 to 21  $\mu$ , late divergentes.

Hab. in foliis *Lawsoniae albae* Lamk. Pusa, 19-10-1906, leg. Inayat Khan (Typus).

Spots numerous, circular, some coalescing into whitish to light brown patches. Acervuli black, subepidermal, amphigenous, erumpent, minute, 54-96  $\mu$  in diameter. Conidia five-celled, fusiform to elliptic, fusoid, usually erect, constricted at septa, 14.8-25.9  $\mu$ ; median cells three, olivaceous, equally coloured, 11.1-14.8  $\times$  3.7-7.4  $\mu$ ; middle cell 3.7-5.5  $\times$  3.7-7.4  $\mu$ . Setae 2, 8 to 21  $\mu$ , widely divergent.

On leaves of *Lawsonia alba* Lamk. Pusa, 19-10-1906 (leg. Inayat Khan) (type). Type deposited in the Herb. Crypt. Ind. Orient. New Delhi.

MONOCHAETIA Sacc. Syll. Fung. 18: 485. 1906.

(As a sub-genus, Sacc. Syll. Fung. 3: 798. 1884.)

## 28. MONOCHAETIA MALI (Ellis & Ev.) Sacc. & D. Sacc. Syll. Fung. 18: 485. 1906.

Syn. *Pestalotia Mali* Ellis & Ev. Jour. Myc. 8: 13. 1902.

On living and blighted leaves of *Pyrus Malus* L. Almora (Kumaon), 3-10-1919 (S. D. Joshi).

## 29. MONOCHAETIA DEPAZEOIDES (Oth) Sacc. Syll. Fung. 18: 485. 1906.

Syn. *Pestalotia depazeoides* Otth, Mitt. Naturf. Ges. Bern p. 68. 1868.

On living leaves of *Rosa moschata* L. Achibal (Kashmir), 20-8-1908 (E. J. B.).

#### IMPERFECTLY DETERMINED SPECIES

##### 30. *PESTALOTIA* sp.

On living leaves of *Terminalis paniculata* Roth. Sirsi (North Kanara), Oct. 1919 (L. J. Sedgwick). Spores measured in 1919 were found to be  $13.2-22 \times 4.4-8.8 \mu$ . At present all mature spores have fallen off and it is not possible to identify the fungus.

##### 31. *PESTALOTIA* sp.

On living leaves of *Eucalyptus globulus* Labill. at Coonoor (Nilgiris), 1917 (McRae). McRae (1917) placed the fungus in *Pestalotia funerea* but this species is now restricted to the Coniferae. There are four species on *Eucalyptus* but it is not possible to determine this fungus correctly for want of mature spores.

#### SPECIES NOT SEEN OR AVAILABLE

##### 32. *PESTALOTIA FUSCESCENS* Sorauer, Pflanzenkrankh. 2a. ed. II, 1886, 399-400. (Butler & Bisby, 1931, p. 159.)

On young plants of *Livistona* (*Corypha*) *australis* R. Br. exported from India to Germany.

##### 33. *PESTALOTIA CAFFRA* Sydow, Ann. Myc. 12: 266. 1914. (Upal, Patel & Kamat, 1935, p. 27.)

On leaves of *Mimusops elengi* L. Dapoli (Bombay Presidency).

#### SUMMARY

This paper records the result of an investigation of the species of *Pestalotia* and *Monochaetia*, collected by E. J. Butler and his colleagues over a period of nearly twenty years in India and Burma. The investigation has shown that there are thirty-one species of

*Pestalotia* and two of *Monochaetia* in these two countries. Of the thirty-one species of *Pestalotia*, two were not available for examination, two were in a very imperfect state so that their specific determination could not be made. Of the rest, four are proposed as new species: *P. Taslimiana*, *P. Citri*, *P. pipericola* and *P. Lawsoniae*.

We wish to express our gratitude to Dr. N. L. Bor, Forest Botanist, Dehra Dun, for his kindness in translating the diagnoses of the new species into latin.

HERB. CRYPT. IND. ORIENT,  
IMPERIAL AGRICULTURAL RESEARCH INSTITUTE,  
NEW DELHI, INDIA

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## ELSINOË IN UGANDA

ANNA E. JENKINS AND A. A. BITANCOURT

(WITH 1 FIGURE)

Uganda has proved a rich collecting ground for species of *Elsinoë* (4) as shown by Hansford's (3) description of seven new species from that region, together with mention of several other species also found there. Among the latter group are *E. Canvaliae* Rac.? on *Dolichos lablab*, recently described as a distinct species, *E. Dolichi*, by Jenkins, Bitancourt and Cheo (5), *E. Fawcetti* Bitancourt and Jenkins (1) on *Citrus*, and *E. Tephrosiae* Hansford (2) on *Tephrosia candida*.

The new species described are *E. Piperis* on *Piper capense* (*Piperaceae*); *E. Adeniae*, *E. antiaridis* and *E. Urerae* on *Adenia* sp., *Antiaridis toxicaria*, and *Urera camerunense*, respectively, of the *Urticaceae*; *E. Pseudospondiadis* on *Pseudospondias microcarpa* (*Anacardiaceae*), *E. Tylophorae* on *Tylophora* sp. (*Asclepiadaceae*) and *E. Chandleri* on *Mikania scandens* (*Compositae*). In addition *Elsinoë* sp. is reported on *Stercospermum kunthianum*. Specimens of these seven new species with the exception of *E. Tylophorae* were contributed to the writers by Hansford before the descriptions were published and they are filed in the Mycological Collections of the Bureau of Plant Industry and in the Seção Fitopatologia, Instituto Biológico, São Paulo, Brazil.

Upon discovering still another species of *Elsinoë* in Uganda in September 1940, Hansford sent an ample gathering of this to the writers with the request that they prepare the diagnosis. In recognition of Hansford's notable discoveries of fungi of this pathogenic group in Uganda this species will be designated in his honor. The description follows:

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FIG.-1. *Elsinoë Hansfordii* on *Scutia myrtina* Kurz., Uganda, September 1940, C. G. Hansford 2819. A, Infected leaves, lower surface, XI; B, Enlarged scabs,  $\times 12$ ; C, Section through an ascoma,  $\times 500$ . Photographs by M. E. F. Foubert (A and B) and by Bitancourt (C).

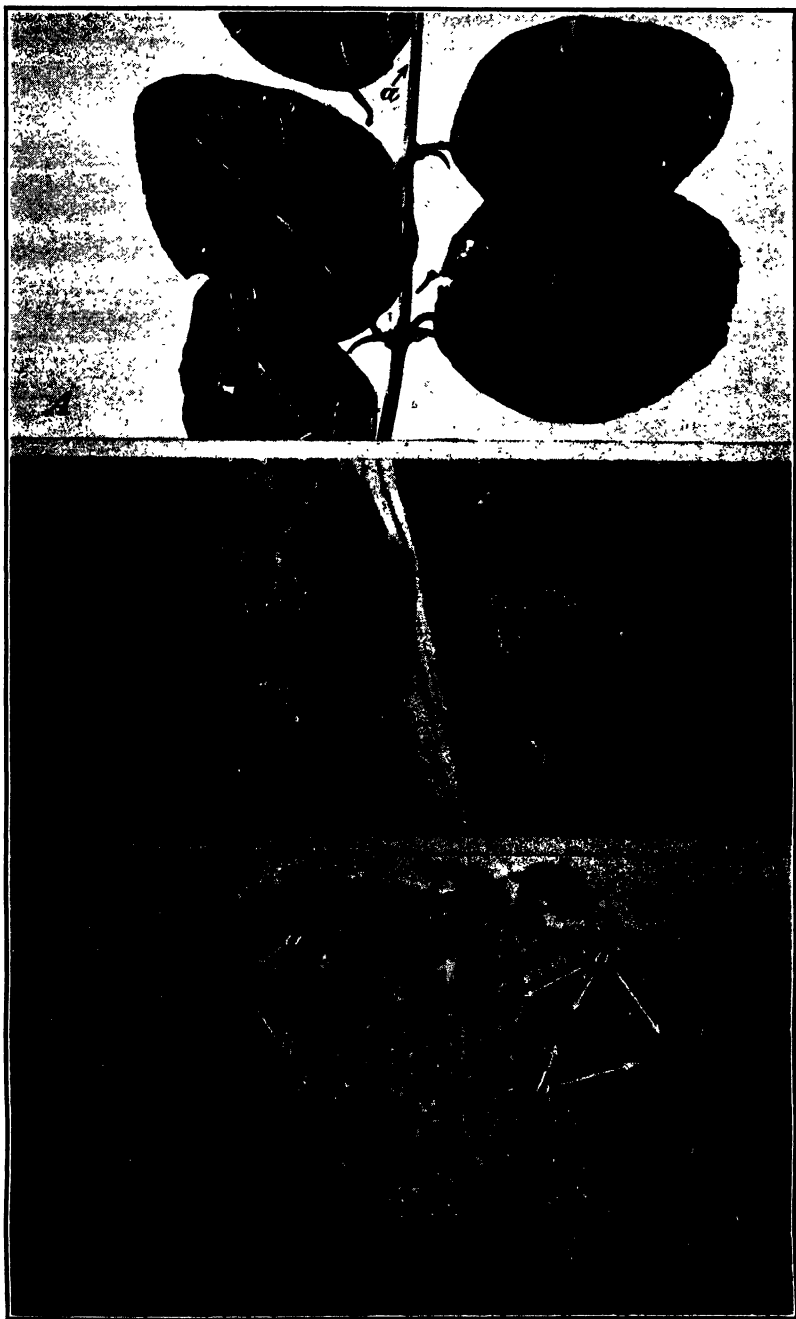


FIG. 1.



**Elsinoë Hansfordii** sp. nov. (FIG. 1).

Scabs hypophyllous (where scabs have been eaten by insects, a light spotting on upper leaf surface), prominent, distinct from the surrounding healthy tissue of the leaf, roundish or irregular, with rough uneven surface, sayal brown (6), light seal brown (6), or, when densely covered with ascomata, nearly black, 0.2 mm.-3 mm. in diam., hyperplastic scab well delimited from the healthy tissues of the leaf by a well developed generating layer, cells of outer part of hyperplastic tissue more or less filled with gum; ascomata numerous on the surface of the scabs, scattered or densely crowded and almost coalescent, pulvinate or more or less globose; dark brown to black, sometimes almost completely covering the surface of the scab; as seen in cross section composed of a more or less homogenous hyaline, yellowish, or, more often, brown pseudoparenchyma, 75-150  $\mu$  in diam. by 60-100  $\mu$  thick, outermost cells slightly darker and thicker but not forming a well defined epithecium; asci scattered in one or two irregular layers in the pseudoparenchyma, thick walled, especially at the apex, 16-22  $\mu$  in diam., with up to 8 ascospores; ascospores hyaline, 1-septate (probably immature), with upper cell broader than the lower cell, 12-15 by 4-6  $\mu$ ; hyaline oblong biguttulate conidia 5-8 by 2-3  $\mu$ , interpreted as those of the imperfect stage, present on the surface of the ascomata.

Verrucae hypophyllae, prominentes, brunneae, interdum ascomatibus dense tectae et fere nigrae, 0.2-3 mm. diam.; ascomata numerosa in superficie verrucarum dispersa vel dense conferta et fere coalescentia, pulvinata vel plus minusve globosa, nigro-brunnea usque nigra, interdum superficiam totam verrucae supertegentia, e pseudoparenchyma hyalina, flavidula vel saepius brunnea composita, 75-150  $\mu$  in diam., 60-100  $\mu$  crassa, cellulis externis crassioribus et obscurioribus sed epithecio definito absente; asci in stratis uno vel duobus pseudoparenchymatis conspersi, 16-22  $\mu$  in diam.; ascosporae hyalinae, uniseptatae (probabiliter immaturae), cellula superiore latiori, 12-15  $\mu$  longae, 4-6  $\mu$  lati; conidia hyalina, oblonga, biguttulata, 5-8  $\mu$  longa, 2-3  $\mu$  lata, in superficie ascomatum praesentia; verisimiliter status imperfectus.

Distribution: On leaves and stems of *Scutia myrtina* Kurz. (Rhamnaceae), Uganda.

SPECIMEN EXAMINED: Kiterera, Busoga, Uganda, September 1940, C. G. Hansford 2819. Part serving as the type divided between Mycological Collections of the Bureau of Plant Industry.

Washington, D. C. (No. 73727) and Secção de Fitopatologia, Instituto Biológico, São Paulo, Brazil (No. 4123).

BUREAU OF PLANT INDUSTRY,  
WASHINGTON, D. C.

AND  
INSTITUTO BIOLÓGICO,  
SAO PAULO, BRIZIL

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## A NEW YELLOW LEPIOTA

VERA K. CHARLES

The fungus described in this paper was found in an orange grove near Orlando, Fla., during January 1941. Attention was attracted to it because of its bright orange color which rendered it conspicuous against the dark background of the dead wood on which it was growing. Its resemblance to a miniature puff-ball was very striking, but with the aid of a hand lens the presence of gills could be discerned. Only two or three individuals were present on the piece of wood when collected but more developed later when the wood was placed in a damp chamber. Although additional pieces of wood in the near vicinity were examined no more specimens were found. In the early unexpanded stage before any appearance of stipe, the resemblance to *Lycoperdon gemmatum* was very marked, the only difference being in the color which in the fungus described here was orange-yellow instead of white as in *Lycoperdon gemmatum*.

The generic position of the fungus was puzzling as the characters are not clearly typical of any one genus. A cobwebby ring is present in the young condition but is evanescent and soon disappears. The hymenophore is not definitely discrete as in most species of *Lepiota* and the gills are adnate, which, however, is true in certain species of *Lepiota*.

A search was made of the literature, including newly described species of *Lepiota*, both North American and tropical, but no species was found which agreed with the Florida collection. Beeli<sup>1</sup> in his work on "Champignons du Congo" described several yellow species but none agree both macroscopically and microscopically with the fungus discussed here. *Lepiota gemmata* described by

<sup>1</sup> Beeli, M. Flore Iconographique des Champignons du Congo, fasc. 2, Brussels 1936.

FIG. 1. *Lepiota aurantiogemmata*. A, two mature plants and small undeveloped specimen shown enlarged in B, nat. size; B, early stage showing arachnoid ring,  $\times 10$ .

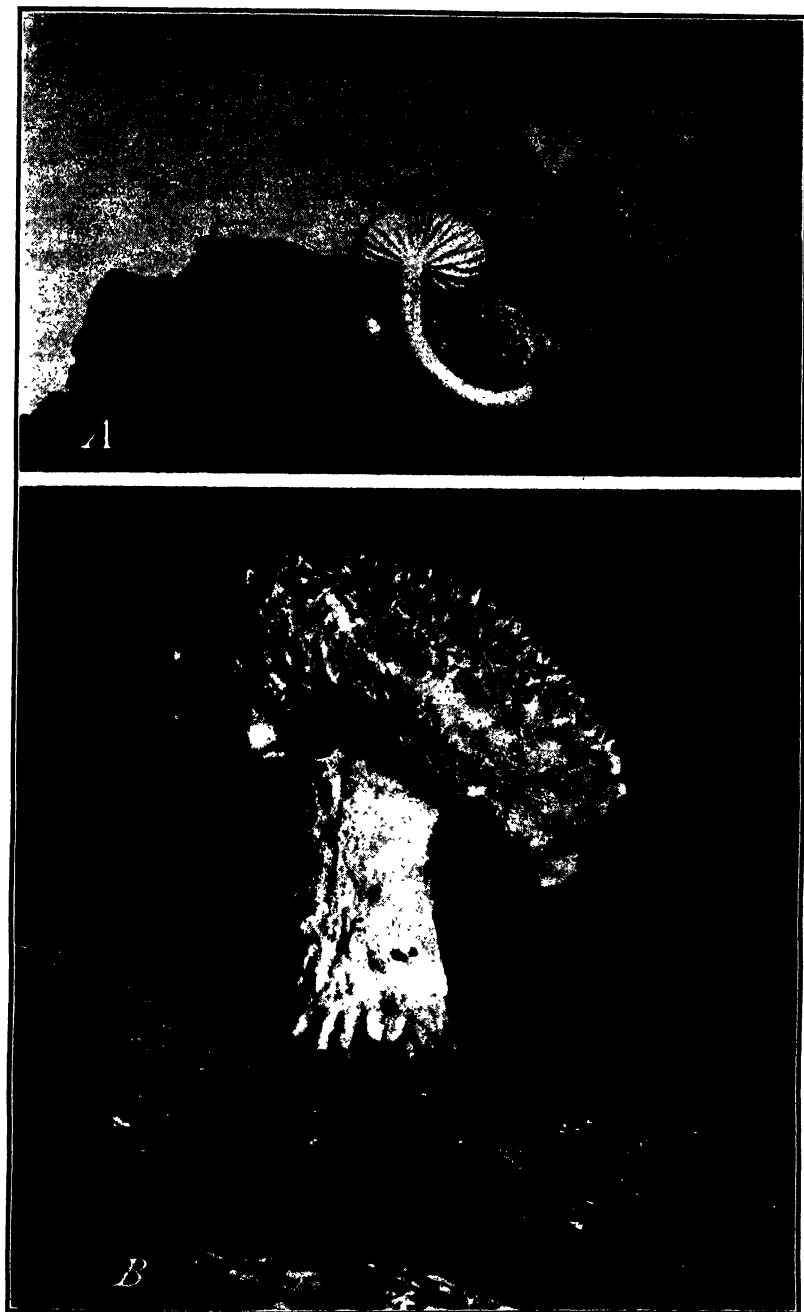


FIG. 1.

Morgan and so-called because of its resemblance to *Lycoperdon gemmatum* in the undeveloped stages was compared but in addition to the difference in color, *Lepiota gemmata* being white, there is a difference in the gills and spores. *Lepiota scabrivelata* Murr. belonging to the section *Acutesquamosae* collected at New Orleans, La., suggests the Florida material but is paler in color, has an ample though not persistent ring and smaller spores. The fungus discussed here is considered new and described as follows under the name of *L. aurantiogemmata* a reference to the color and shape of the pileus.

***Lepiota aurantiogemmata* Charles & Burlingham sp. nov.**

Pileo 1.5–2.5 cm. lato, aurantiaco-luteo, tomentoso, tomento ex fibris in caespites pyramidatos aggregatis, composito, margine involuto fibrilloso: cortina arachnoidea supera, fibrillosa, fugaci: lamellis albidis, denum pallide flavis, adnatis, inaequalibus, subdistantibus: stipite 2–2.5 cm. longo, 1.5–2 mm. lato, flocculoso-squamoso, peronato: sporis apiculatis, subglobois v. ovoideis  $6.25\text{--}6.85 \times 8.75 \mu$ , reticulatis: cystidiis paucis, crasse tunicatis,  $34\text{--}38 \mu$  longis, lageniformibus, apice subcoronatis.

Hab. ad lignum emortuum.

Pileus orange-yellow, 1.5–2.5 cm. broad, covered with orange-yellow tomentum, the fibers of which unite at the apex to form pyramidal clusters, margin at first incurved felty-tomentose; ring cobwebby, composed of fine fibers at the apex of the downy fibrous covering of the stem, evanescent; gills white, later pale yellow, adnate, unequal, rather distant: stipe 2–2.5 cm. long, 1.5–2 mm. in width, peronate with soft fibers: spores subsphaerical to oval, apiculate  $6.25\text{--}6.85 \times 8.75 \mu$ , reticulate with iodine: cystidia few, large  $34\text{--}38 \mu$  projecting beyond the basidia, flaskshaped, apex thickened, slightly coronate.

Type collected on dead wood near Orlando, Fla., Jan. 25, 1941, G. S. Burlingham and V. K. Charles. Deposited in the Mycological Collections of the Bureau of Plant Industry, Washington, D. C. No. 71371.

BUREAU OF PLANT INDUSTRY,  
WASHINGTON, D. C.

# THE INHERITANCE OF INDUCED MUTATIONS IN NEUROSPORA TETRASPERMA

WALTER SCOTT MALLOCH

Natural mutations have been studied in *Neurospora crassa* for nearly a decade (cf. Lindegren, 1932, 1933), but recently X-ray and ultra-violet induced mutations have been investigated in this species (cf. Lindegren & Lindegren, 1941; Beadle & Tatum, 1941). On the other hand, *N. tetrasperma* is more stable, so that it was more convenient, at first, to investigate those mutations which were the result of high frequency radiation (cf. Dodge, 1934, 1935, 1936; Dodge & Seaver, 1938; Malloch, 1941). The nature of this evidence will be discussed before describing the genetic behavior of X-ray induced mutations in this species.

Dodge & Seaver (1938) studied a dominant factor, *I*, for indurated ascus abortion and a recessive factor, *d*, for deliquescent ascus abortion, which originated in an X-ray experiment. In the deliquescent or cytolytic type of abortion, the full quota of asci arise in the ascocarp and become elongated. Then without developing any spores, the asci disintegrate and disappear. In the second type of abortion, asci become chitinized or indurated, dark colored, and striated like the ascospores. Genetic studies could be carried beyond the first generation because some asci matured spores in every ascocarp.

Among the new alterations which have recently been described (cf. Dodge, 1939, 1941) a lethal form occurred in non-irradiated material. The lethal *E* was assumed to be a chromosomal deficiency, which either caused ascus abortion or prevented the germination of those ascospores carrying it. The fourth type was a bright cadmium-yellow dwarf race, which had a very low growth rate and was non-conidial (cf. Dodge, 1941). When this mutation was crossed with another race the growth of the mycelium and conidiospores was increased manyfold.

Dodge (1935) and Tai (1936) reported that a factor *O* for salmon orange conidia was strongly linked with the sex factor *a*, and that a factor *o* for salmon pink conidia was linked with Sex *A*. Since these factors are studied to the best advantage in interspecific hybrids, the genetic formula in this investigation will not be complicated by the addition of these symbols. In addition Tai (1936) reported that a factor *M* for blackening of the substratum is strongly linked to the factor *A*. The color of the substratum was orange or amber in those cultures carrying factor *a*. While the behavior of culture No. 42 can be explained without the use of these symbols, an ascus analysis of dark and light X-rayed derivatives of this species suggested that these alterations were determined by genetic factors. In an investigation of a mating between *N. tetrasperma* and *N. sitophila* Dodge (1936) studied a pair of factors, *Cc*, for the presence and absence of conidia. Since the non-conidial character was introduced into the mating by *N. sitophila*, it is probably different from the brown mycelium type which was discovered in *N. tetrasperma* (cf. Malloch, in press).

It is the aim of this paper to discuss several genetic factors, which were briefly mentioned in two preliminary papers on high frequency radiation (cf. Malloch, 1940, 1941). With the exception, of *Aa*, we believe that the factors reported here differ from those previously reported. As a consequence, there is still no duplication in the symbols used for genetic factors in *N. tetrasperma*. The methods, which have been used in this investigation, have been selected from those already reported (cf. Goodspeed, 1942; Lindegren, 1932; Shear & Dodge, 1927; Uber & Goddard, 1934; Wuekler, 1935), with the exception that ascus dissection was performed by hand with the aid of a flexible gold strip, 0.1 mm. in thickness. This instrument was flexible enough to cut the cluster of asci into several sections without shattering the individual members. The names for the color characters were adopted after comparing the different cultures with Ridgway's Color Standards (1912). Since we have described the genetic factors which are already known for this species the results of the present experiment will now be discussed.

DERIVATIVES OF ONE X-RAYED ASCOSPORE OF  
NEUROSPORA TETRASPERMA

When  $F_2$  populations were grown from the derivatives of X-rayed ascospores of this species, some populations gave evidence of a heterozygous condition. The progeny of one culture, No. 42, attracted particular attention because of the distinctive type of segregation (cf. Malloch, 1941). It was characterized by the absence of conidiospore production, by defective perithecia development, and by the production of a few ascospores. The diploid and haploid derivatives of this distinctive race exhibited several new character combinations. As indicated by the genetic evidence these character combinations are governed by three pairs of genes. An allelomorphic pair of factors,  $Aa$ , determine sex expression,  $A$  being associated with salmon pink (pale), and  $a$  with salmon orange conidiospore color.  $W$  and  $w$  are factors affecting the form of hyphal growth,  $W$  being a dominant factor for normal, and  $w$  being a recessive factor for a dwarf type of growth. The third pair of factors,  $Pp$ , affect several characters,  $P$ , being associated with normal perithecia and ascospore production and a chestnut brown (medium) color in the substratum, and  $p$  with reduced perithecia and ascospore production and a light color in the substratum. In the presence of  $W$ , factor  $p$  conditions fluffy conidiospore growth, but in the presence of  $w$ , conidiospore growth is distinctly reduced or absent. In this paper a series of letters, such as  $aWp$  is understood to represent a unisexual race, and a formula, such as  $\frac{aW}{AW} \frac{P}{P}$ , a bisexual strain. The following diploid and haploid types, which were derived from culture No. 42, were studied in this experiment.

I. The normal orange type. The aerial mycelium and conidial growth were loose and irregular at first but soon formed floccuse masses, which were salmon orange in color. A chestnut brown color developed in the sclerotia and surface mycelium as the culture reached maturity. Numerous hairy sclerotia were present, but perithecia were completely absent. This type has the genetic constitution  $aWP$ , because it has a normal rate of



growth (*W*), and because it is capable of forming normal perithecia (*P*) when mated with the standard Sex *A* strain.

II. The normal pale type was like the preceding, except that conidiospore production was reduced and salmon pink in color. It has the genetic constitution *AWP*, since the rate of growth is normal (*W*), and it forms normal perithecia (*P*) when mated with the standard Sex *a* strain.

III. The fluffy orange type. The aerial mycelium and conidial growth were exceptionally vigorous from the beginning, so that fluffy compact masses were formed, which gradually acquired a salmon orange tint. The clear substratum changed to orange upon reaching maturity. There were numerous colorless sclerotia, but perithecia were absent. It has the genetic constitution *aWp*, because the growth rate is normal (*W*) and the production of perithecia is reduced when mated with *Aw p*.

IV. The light dwarf type was distinguished by a very slow-growing mycelium with short branches. The few conidiospores which did develop were pale in color. Sclerotia and perithecia were lacking in this form. The genetic constitution of this type was *Aw p*, since it has a dwarf type of growth (*w*) and it produces a reduced number of perithecia when mated with the fluffy orange type, *aW p*.

V. The dark dwarf type was like the preceding, with the exception that it was darker in color. This strain has the genetic constitution *Aw P*, because it has a dwarf type of growth (*w*) and it produces perithecia (*P*) and ascospores when mated with *aW P*.

VI. The normal bisexual type. The conidial stage was identical with the normal orange type, but as the culture reached maturity it was characterized by normal perithecia and ascospore production. Since the *W* and *P* factors are dominant, this bisexual form could have any one of the following constitutions:  
 $\frac{aW P}{AW P}, \frac{aW p}{AW P}, \frac{aW P}{AW p}, \frac{aW P}{Aw P}, \frac{aW p}{Aw P}, \frac{aW P}{Aw p}$ .

VII. The light semi-fertile type. The conidial stage was identical with the fluffy orange type with the exception that the conidial mass was orange pink in color. In this respect this strain was intermediate between the salmon orange and salmon

pink colors of types I and II. The light semi-fertile type produced a few slow-developing perithecia with limited ascospore production. As will be shown later the genetic constitution of this form was  $\frac{Aw}{aW} \frac{p}{p}$ .

Four additional types occurred among the progeny of culture No. 42, but these will be described at a later date (cf. Malloch, in press).

#### THE GENETIC BEHAVIOR OF TYPES I TO VII

Certain of the unisexual types were crossed with the standard sex strains in order to determine which genes were present. As shown in Table 1, the light dwarf type (culture No. D<sub>1</sub>) was

TABLE 1  
F<sub>2</sub> PROGENY OBTAINED FROM ASCOSPORES WHICH HAD THE  
GENETIC CONSTITUTION  $\frac{aW}{Aw} \frac{P}{p}$

| Number of experiment             | D <sub>1</sub> × Ta<br>1-F <sub>2</sub> | Number of experiment     | D <sub>1</sub> × Ta |                  | D <sub>10</sub> × Ta<br>1-F <sub>2</sub> |
|----------------------------------|---|--------------------------|---------------------|------------------|--|
|                                  |   |                          | 1-F <sub>2</sub>    | 2 F <sub>2</sub> |  |
| Type of asci as shown by progeny |   | Progeny from spore print |                     |                  |  |
| 1.0 All normal . . . . .         | 19                                      | 4.0 All normal . . . .   | 71                  | 49               | 60                                       |
| Unisexual types                  |   | 5.0 Semifertile . . . .  | 23                  | 13               | 18                                       |
| 1.1 $aW P$ . . . . .             | 6                                       | 6.0 Unisexual types      |                     |                  |  |
| 1.2 $Aw p$ . . . . .             |   | $aW P$ . . . . .         | 1                   | 2                | 0  |
| 1.3 $Aw P$ . . . . .             |   | $Aw p$ . . . . .         | 1                   | 1                | 1  |
| 1.4 $aW p$ . . . . .             |   | $Aw P$ . . . . .         | 1                   | 0                | 0  |
| 2.0 Two normal :                 |   | $aW p$ . . . . .         | 2                   | 0                | 2  |
| 3.0 two semifertile . . . .      | 18                                      | Test for $X^2$           | .0005               | .0537            | .0500                                    |
| Unisexual types                  |   | 3 : 1 ratio $P$          | .99-.98             | .90-.80          | .90-.80                                  |
| from normals                     |   |                          |                     |                  |  |
| 2.1 $aW P$ . . . . .             | 2                                       |                          |                     |                  |  |
| 2.2 $Aw P$ . . . . .             |   |                          |                     |                  |  |
| Unisexual types                  |   |                          |                     |                  |  |
| from semifer-                    |   |                          |                     |                  |  |
| tiles                            |   |                          |                     |                  |  |
| 3.1 $aW p$ . . . . .             | 6                                       |                          |                     |                  |  |
| 3.2 $Aw p$ . . . . .             |   |                          |                     |                  |  |
| Test for $X^2$ . . . . .         | .0360                                   |                          |                     |                  |  |
| 3 : 1 ratio $P$ . . . . .        | .90-.80                                 |                          |                     |                  |  |

crossed with the standard sex type (culture No. Ta). The different genotypes obtained from this cross are numbered for convenience of reference (cf. Table 1). Cultures derived from the mating D<sub>1</sub> × Ta produced two types of asci: those producing

four normal bisexual cultures (Table 1, No. 1.0), and those producing two normal bisexual (Table 1, No. 2.0) and two semi-fertile (Table 1, No. 3.0) cultures. The observed frequencies were 19 asci of the first type and 18 of the second, or a proportion of 112 cultures of the normal bisexual type to 36 cultures of the semi-fertile strain. When tested for a 3 : 1 ratio, the chi-square and probability values amounted to .0360 and .90-.80. When progenies were grown from a spore print (cf. Table 1), one population consisted of 71 cultures of the normal bisexual type, and 23 cultures of the semi-fertile type. When tested for the same ratio, the chi-square and *P* values were .0005 and .99-.98. Data in Table 1 show that other populations behaved in a similar fashion. Judging by the chi-square tests there is reason to believe that these characters segregate according to a 3 : 1 ratio. This ratio, however, is produced by a different method from that found in higher plants and animals.

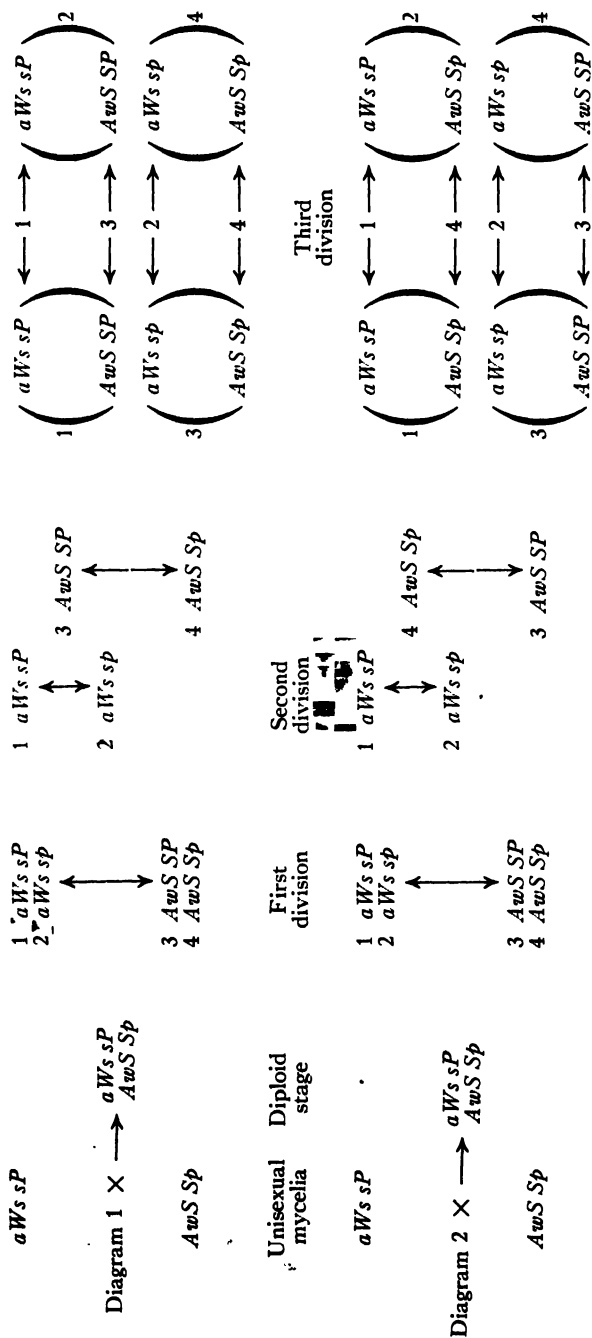
In order to explain the segregation of genetic characters in *Neurospora tetrasperma*, diagrams similar to those given by Lindegren (1933) and Dodge (1936) have been constructed. The chromosomes are represented by letters, such as *aWs sP*, for the known genetic factors. The spindle-fiber attachment of one member of a homologous pair of chromosomes is represented by *S* (or *SS*), and that of the second member by *s* (or *ss*). Crossing-over can be shown by means of these letters, but since the spindle-fiber attachment is probably inert, the segregation of these symbols can be neglected or omitted in the interpretation of the genotype.

The genetic constitution of the unisexual mycelia entering into a cross is indicated in the first vertical column, while the constitution of the diploid cell in the ascus hook is shown in the second column. The products resulting from segregation in the first division are shown in the third column. Lines 1 and 2 or 3 and 4 of the third column represent the two chromatids of a chromosome. The four chromatids have been numbered so that their behavior in the second and third divisions can be followed. The second and third divisions are shown in columns four and five respectively. In the diagram, the two non-sister nuclei which form a bisexual ascospore are enclosed by brackets. The

fourth division has been omitted from the diagram since it is an equational type. It is understood that the arrangement in the ascus is uniseriate at maturity, due to a turning and slipping of the spores as soon as they are finally cut out (cf. Dodge, 1927). This arrangement of the spores in the ascus is represented by numbers on the outside of the brackets.

The correspondence between cytological and genetic behavior can be shown by considering the different types of segregation which are possible in a homothallic ascomycete. In the first place, we may consider the behavior of those factors which do not undergo crossing-over. This phenomenon does not occur when a factor is located close to the spindle-fiber attachment or when an inversion of the right dimension has taken place. The absence of crossing-over in the sex factors is indicated in Diagram 1 by continuing to place the *a* factors in the same chromatids with the *s* spindle-fiber attachment. It may be noted that any other factor, such as *W*, which is closely linked to *a* will segregate in the same way. As a consequence of this phenomenon and the fact that non-sister nuclei cooperate in spore formation, every spore will contain an *A* and *a* factor, and all of the resulting bisexual spores will appear alike. The constitution of the unisexual ascospores can be determined by considering each of the eight nuclei in the third division as a spore. In Diagram 1, for instance, the uninucleate ascospores could have any one of the following formulae: *aWs sP*, *aWs sP*, *AwS SP*, *AwS SP*, *aWs sp*, *aWs sp*, *AwS Sp*, *AwS Sp*.

We may now consider the behavior of two factors, which are located upon separate chromosomes, assuming that crossing-over does not occur in either factor. Two types of first-division spindles can be obtained, since the second factor, *P*, may go to the same pole as the factor for Sex *a*, or to the same pole as the factor for Sex *A*. Due to the incorporation of non-sister nuclei in the same ascospore, all of the bisexual types would contain the same genetic factors, so that the segregation of genetic characters could not occur in these cultures. By constructing diagrams in which two factors, *a* and *p*, behave like the sex factors in Diagrams 1 and 2 it could be shown that different types of unisexual cultures would be obtained. For instance,



when  $p$  goes to the same pole as  $Aw$ , the following haploid ascospores would be produced: light dwarf,  $AwS Sp$ , and the normal orange type,  $aWs sP$ . When  $P$  goes to the same pole as Sex  $A$ , the following types of unisexual ascospores should be obtained, the dark dwarf,  $AwS sP$ , and the fluffy orange type,  $aWs Sp$ .

The effect of crossing-over on the segregation of genetic characters in *N. tetrasperma* will now be considered. It will be assumed that the  $Pp$  factors show fifty per cent crossing-over with the spindle-fiber attachment, but that the  $Aa$  factors do not show this phenomenon. As shown by the diagrams, the spindles have an oblique arrangement in the second division. When the spindles are oriented in the same direction, two asci will be homozygous for  $P$ , and two will be homozygous for  $p$  (cf. Diagram 1). If the second spindle is just reversed from the first one, all of the ascospores will contain the factor pair  $Pp$  (cf. Diagram 2) and, hence, all of the resulting cultures should appear alike. Two other arrangements are possible in that each spindle may be reversed in both cases. For instance, the two spores which are homozygous for  $P$  may be in the blunt end of the ascus in one case and in the narrow end in the second case. When crossing-over occurs in one factor only, the same end result is obtained regardless of whether the two factors are located upon one or two chromosomes. Since the  $Pp$  factors are the only ones in which crossing-over occurs, it will be unnecessary to discuss double crossing-over until a later date (cf. Malloch, in press).

Since it is known from cytological studies that the spindles may sometimes have a longitudinal arrangement in the second division (cf. Dodge, 1927, 1936), instead of the oblique type shown in Diagrams 1 and 2, it is necessary to consider the genetic effect of such an arrangement. We will discuss a case in which two factors are located upon different chromosomes of this species. When  $p$  goes to the same pole of the spindle as  $A$ , assuming that no crossing-over occurs, the four ascospores would have the following constitution,  $\frac{aWs sP}{aWs sP}$ ,  $\frac{aWs sP}{aWs sP}$ ,  $\frac{AwS Sp}{AwS Sp}$ ,  $\frac{AwS Sp}{AwS Sp}$  (cf. Diagram 3), but when  $p$  goes to the same pole as



*a* the formula of the ascospores would be  $\frac{aWs Sp}{aWs Sp}, \frac{aWs Sp}{aWs Sp}, \frac{AwS sP}{AwS sP}, \frac{AwS sP}{AwS sP}$ . Since the occurrence of two factors of the same sex reaction in one ascospore would cause sterility, this type of behavior is not typical for untreated cultures of *N. tetrasperma*.

It may now be assumed that the spindles have a longitudinal arrangement in the second division and that the *A* and *p* factors show fifty per cent crossing-over with the spindle-fiber attachment. Since it is evident from an inspection of Diagram 4, that every ascospore would contain a dominant and a recessive factor, this method of segregation can not explain the results of this experiment. If it is assumed, however, that the *A* factor shows fifty per cent and that the *p* factor shows twenty-five per cent crossing-over with the spindle-fiber attachment a different result is obtained. According to this hypothesis all of the resulting cultures would show some fertility because all of the ascospores would contain an *A* and *a* factor. As far as the *p* factor is concerned half of the asci would segregate according to the method shown in Diagram 3, and half according to the method shown in Diagram 4. Those segregating according to the first method would consist of two normal and two semi-fertile cultures, whereas those segregating according to the second method would consist of four normal cultures. When reduced to the simplest terms these results give a ratio of three normal to one semi-fertile culture. When segregation occurs according to Diagram 4, double crossing-over must also be considered. Since there are three ways in which this phenomenon can occur, progressive, independent and recurrent, the constitution of the ascospores for these three types would be  $\frac{aWs sP}{Aws sp}, \frac{aWs sP}{Aws sp}, \frac{aWS Sp}{AwS SP}, \frac{aWS Sp}{AwS SP}$  or  $\frac{aWs sp}{Aws sP}, \frac{aWs sp}{Aws sP}, \frac{AwS SP}{aWS Sp}, \frac{AwS SP}{aWS Sp}$ ; or  $\frac{aWs sP}{Aws sp}, \frac{aWs sP}{Aws sp}, \frac{aWS SP}{AwS Sp}, \frac{aWS SP}{AwS Sp}$  respectively. As a consequence, the same types of unisexual spores would be obtained as those shown in Table 1. Additional evidence on these two



theories will be forthcoming (cf. Malloch, in press). At this time the behavior of several  $F_3$  progenies, which were grown from the cultures described in Table 1, will be presented.

The asci (cf. Table 1, Nos. 2.0–3.0) which segregated into two normal and two semi-fertile cultures will be considered first. This category consists of two bisexual and four unisexual types which will be discussed in turn. When  $F_3$  generations were grown from four of the semi-fertile cultures (cf. Table 1, No. 3.0), the resulting bisexual cultures were all semi-fertile,  $\frac{Aw\ p}{aW\ p}$ , while the unisexual cultures consisted of the fluffy orange,  $aW\ p$ , and the light dwarf types,  $Aw\ p$ . Since the semi-fertile cultures bred true to type, they must be homozygous for the  $p$  factor. The genetic constitution of the semi-fertile type was confirmed by the isolation of the unisexual types (cf. Table 2). When the

TABLE 2  
 $F_2$  PROGENY OBTAINED FROM ASCOSPORES WHICH HAD THE  
 GENETIC CONSTITUTION  $\frac{aW\ p}{Aw\ p}$

| Number of experiment             | 75- $F_2$ | $D_1 \times Ta$<br>76- $F_2$ | 78- $F_2$ | 79- $F_2$ | $W_{81} \times Ta$<br>1- $F_2$ |
|----------------------------------|-----------|------------------------------|-----------|-----------|--------------------------------|
| Type of asci as shown by progeny |           |                              |           |           |                                |
| 1A Semifertile . . . . .         | 15        | 18                           | 17        | 12        | 14                             |
| Unisexual $aW\ p$ . . . . .      | 3         | 4                            | 3         | 1         | 5                              |
| types $Aw\ p$ . . . . .          | 0         | 1                            | 0         | 0         | 0                              |
| Progeny from spore print         |           |                              |           |           |                                |
| 1B Semifertile . . . . .         | 23        | 28                           | 81        | 51        | 63                             |
| Unisexual $aW\ p$ . . . . .      | 15        | 6                            | 9         | 8         | 2                              |
| types $Aw\ p$ . . . . .          | 4         | 5                            | 7         | 3         | 1                              |

fluffy orange (cf. Table 1, No. 3.1) and the light dwarf types (cf. Table 1, No. 3.2) were mated, the  $F_1$  hybrid exhibited the characteristics of the semi-fertile type. Since the  $F_2$  generation of this mating again bred true to the semi-fertile condition, the behavior of this type is completely established. In *N. tetrasperma*, the unisexual types represent but a small proportion of the population, and since they are slow in developing, it is frequently necessary to isolate them from spore prints.

The analysis of the normal bisexual cultures (cf. Table 1,

No. 2.0) which had the genetic constitution  $\frac{aW}{Aw} \frac{P}{P}$  will be considered next. As shown in Table 3 seven  $F_3$  progenies consisted of the normal bisexual, the normal orange and the dark dwarf types. Since the bisexual cultures bred true to type, they must be homozygous for the  $P$  factor. The isolation of the two unisexual types, which were theoretically expected, confirm the genetic constitution of the bisexual cultures. The behavior of the two unisexual strains will now be considered.

TABLE 3

$F_3$  PROGENY FROM THE HYBRID MATING  $Ta \times D_1$

The ascospores from which these cultures were raised had the genetic constitution  $\frac{aW}{Aw} \frac{P}{P}$ .

| Number of experiment                | $Ta \times D_1$ |                 |                 |                 |                 |                  |                  |
|-------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------------|------------------|
|                                     | 2F <sub>3</sub> | 4F <sub>3</sub> | 5F <sub>3</sub> | 6F <sub>3</sub> | 9F <sub>3</sub> | 12F <sub>3</sub> | 13F <sub>3</sub> |
| Type of asci as shown by progeny    |                 |                 |                 |                 |                 |                  |                  |
| All normal bisexual types . . . . . | 23              | 18              | 19              | 14              | 17              | 16               | 12               |
| Unisexual types $aWP$ . . . . .     | 1               | 2               | 1               | 3               | 4               | 5                | 1                |
| $AwP$ . . . . .                     | 1               | 0               | 0               | 0               | 0               | 0                | 0                |
| Progeny obtained from a spore print |                 |                 |                 |                 |                 |                  |                  |
| All normal bisexual types . . . . . | 110             | 47              | 46              | 46              | 59              | 57               | 86               |
| Unisexual types $aWP$ . . . . .     | 4               | 2               | 2               | 4               | 16              | 1                | 6                |
| $AwP$ . . . . .                     | 5               | 4               | 4               | 5               | 20              | 1                | 3                |

When the normal orange unisexual type,  $aWP$  (cf. Table 1, No. 2.1), was mated with the standard sex strain,  $AWP$  (No. TIA), the  $F_1$  generation resembled the normal bisexual type. The  $F_2$  progeny from this cross consisted of 55 normal bisexual cultures, two normal orange,  $aWP$ , and three normal pale,  $AWP$ , types. Since the rate of growth was normal in each derivative type, the factor  $W$  must have been present in each strain. The presence of factor  $P$  was confirmed by the occurrence of normal perithecia and ascospore production.

The dark dwarf type,  $AwP$  (cf. Table 1, No. 2.2), grew at the same rate as the light dwarf type, but it reacted in a different way. When this unisexual type was mated with the normal orange type,  $aWP$  (cf. Table 1, No. 2.1), the  $F_2$  generation consisted of normal bisexual cultures, the normal orange type and

the dark dwarf type (cf. Table 4). In this cross the factor *W*, which was introduced by the normal orange type was completely dominant over the *w* factor. The occurrence of normal perithecia and ascospore production in all of the progeny indicated that each unisexual type carried factor *P*. These experiments complete the analysis of those asci which segregated into two normal and two semi-fertile cultures.

TABLE 4  
RESULTS OBTAINED FROM A MATING BETWEEN THE DARK DWARF  
TYPE *AwP* AND THE NORMAL ORANGE TYPE *aWP*

| Number of experiment                 | D39 × Y17 | D39 × Y18 |
|--------------------------------------|-----------|-----------|
| Type of asci as shown by progeny     |           |           |
| All normal bisexual types . . . . .  | 13        | 14        |
| Unisexual types <i>aWP</i> . . . . . | 2         | 1         |
| <i>AwP</i> . . . . .                 | 0         | 0         |
| Progeny derived from a spore print   |           |           |
| Normal bisexual types . . . . .      | 79        | 75        |
| Unisexual types <i>aWP</i> . . . . . | 6         | 8         |
| <i>AwP</i> . . . . .                 | 7         | 2         |

Those asci which produced all normal cultures in the cross between the light dwarf type and the standard sex strain (cf. Table 1, No. 1.0) will be analyzed in the same way. Nine progenies which were grown from the bisexual cultures are shown in Table 5. These segregated in a ratio of 3 normal bisexual to 1 semi-fertile culture in addition to producing the normal orange, the dark dwarf, the fluffy orange and the light dwarf types. Additional progenies which were grown from spore prints are shown in Table 6. The chi-square and *P* values listed in Tables 5 and 6 indicate that there was good agreement between the expected ratio of 3 : 1 and the observed facts. The unisexual strains belonging to this category will now be discussed.

When the normal orange unisexual type, *aWP* (cf. Table 1, No. 1.1), was mated with the standard sex strain, No. TIA, the progeny consisted of 83 normal bisexual cultures, two normal orange and three normal pale unisexual cultures. Since this mating was homozygous for all factors except the *Aa* pair, it confirms the nature of one of the unisexual types postulated in  
\*Diagrams 1 and 2.

TABLE 5

F<sub>2</sub> PROGENIES RAISED FROM THE NORMAL F<sub>2</sub> CULTURES OF THE  
MATING Ta × D<sub>1</sub>

The ascospores from which these cultures were raised had the genetic constitution of  $\frac{aW}{Aw} \frac{p}{P}$  or  $\frac{aW}{Aw} \frac{P}{p}$ .

| No. of experiment                      | 1-F <sub>2</sub>         | 3-F <sub>2</sub> | 7-F <sub>2</sub> | 8-F <sub>2</sub> | 10-F <sub>2</sub> | 11 F <sub>2</sub> | 14-F <sub>2</sub> | 15-F <sub>2</sub> | 17 F <sub>2</sub> |
|--|--------------------------|------------------|------------------|------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Type of asci as shown by progeny       |                          |                  |                  |                  |                   |                   |                   |                   |                   |
| 1. All normal . . . . .                | 13                       | 15               | 16               | 16               | 13                | 19                | 16                | 13                | 14                |
| Unisexual <i>aW P</i>                  | 4                        | 4                | 3                | 2                | 2                 | 5                 | 2                 | 1                 | 2                 |
| forms <i>Aw p</i>                      | 0                        | 0                | 0                | 0                | 0                 | 0                 | 0                 | 0                 | 0                 |
| <i>Aw P</i>                            | 0                        | 0                | 0                | 0                | 0                 | 0                 | 0                 | 0                 | 0                 |
| <i>aW p</i>                            | 0                        | 0                | 0                | 0                | 0                 | 0                 | 0                 | 0                 | 0                 |
| 2. Two normal : two semi-fertile . . . | 11                       | 10               | 13               | 14               | 10                | 15                | 15                | 10                | 12                |
| Unisexual <i>aW P</i>                  | 1                        | 2                | 1                | 3                | 1                 | 1                 | 0                 | 1                 | 2                 |
| forms <i>Aw P</i>                      | 0                        | 0                | 0                | 0                | 0                 | 0                 | 0                 | 0                 | 0                 |
| <i>aW p</i>                            | 2                        | 2                | 4                | 3                | 1                 | 4                 | 4                 | 3                 | 2                 |
| <i>Aw p</i>                            | 0                        | 0                | 0                | 0                | 0                 | 0                 | 0                 | 0                 | 0                 |
| Test for 3 : 1                         | X <sup>2</sup> . . .2223 | 1.3333           | .4137            | .1777            | .5217             | .6275             | .0431             | .5217             | .7619             |
| ratio                                  | P . . . .                | .30-             | .70-             | .70-             | .50-              | .50-              | .90-              | .50-              | 50-               |
|  |                          | .50              | .20              | .50              | .50               | .30               | .50               | .80               | .30               |

TABLE 6

THESE PROGENIES ARE THE SAME AS SHOWN IN TABLE 5 BUT THE  
ASCOSPORES WERE OBTAINED FROM A SPORE PRINT

| No. of experiment                 | 1-F <sub>2</sub>         | 3-F <sub>2</sub> | 7-F <sub>2</sub> | 8-F <sub>2</sub> | 10-F <sub>2</sub> | 11-F <sub>2</sub> | 14-F <sub>2</sub> | 15-F <sub>2</sub> | 17-F <sub>2</sub> |
|-----------------------------------|--------------------------|------------------|------------------|------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Progeny obtained from spore print |                          |                  |                  |                  |                   |                   |                   |                   |                   |
| 1. Normal bisexual                | 66                       | 38               | 37               | 34               | 28                | 46                | 60                | 64                | 52                |
| 2. Semi-fertile . . . .           | 18                       | 9                | 8                | 8                | 7                 | 8                 | 17                | 23                | 11                |
| 3. Unisexual <i>aW P</i>          | 2                        | 2                | 5                | 8                | 5                 | 1                 | 4                 | 10                | 3                 |
| <i>Aw p</i>                       | 1                        | 2                | 1                | 2                | 1                 | 2                 | 4                 | 2                 | 3                 |
| <i>Aw P</i>                       | 1                        | 3                | 0                | 1                | 2                 | 3                 | 2                 | 5                 | 0                 |
| <i>aW p</i>                       | 6                        | 3                | 3                | 6                | 2                 | 0                 | 9                 | 4                 | 6                 |
| Test for 3 : 1                    | X <sup>2</sup> . . .5715 | .8521            | 1.2519           | .7936            | .4667             | 2.9876            | .3507             | .0957             | 1.9100            |
| ratio                             | P . . . .                | .50-             | .30-             | .50-             | .50-              | .10-              | .70-              | .80-              | .20-              |
|                                   |                          | .30              | .30              | .20              | .30               | .30               | .05               | .50               | .70               |

When the light dwarf segregate (cf. Table 1, No. 1.2) was mated to the standard sex strain No. Ta, an F<sub>2</sub> population was obtained (D<sub>46</sub> × Ta), which segregated into a ratio of sixty normal bisexual to eighteen semi-fertile cultures. This mating followed the type of segregation shown in Diagrams 1 and 2 and confirmed the nature of the light dwarf segregate.

By analyzing the bisexual and unisexual types from an X-rayed derivative of *N. tetrasperma*, it has been shown that the new

alterations behaved like gene mutations. This was true regardless of whether the mutant types were mated between themselves or with the standard sex strains. The only point which was not determined was the linkage relationships of the  $p$  factor. Since  $p$  was the only factor which exhibited crossing-over in these matings, it was immaterial whether this factor was located upon the same chromosome with  $A$ , or upon a separate one. This question will be discussed in the next paper, because the linkage groups can be described to the best advantage in connection with the four remaining types derived from culture No. 42.

#### DISCUSSION

While fertilization and meiosis are the two important phases in the genetic behavior of seed plants, the method of spore formation may play an important role in the development of fungi. This is true in *Neurospora* because in this group both homothallic and heterothallic species are found. In both groups there are two types of haploid nuclei, each of which contains one set of chromosomes. One chromosome of each set carries either an  $A$  or  $a$  factor. Both heterothallic and homothallic species produce eight nuclei in the ascus as a result of three nuclear divisions. The important difference between the two groups, however, occurs at the time of spore formation, for this is the process which determines whether the ascospores and resulting mycelium shall be monocaryotic or dicaryotic in nature.

Since the ascospores of *N. crassa* are monocaryotic, the question of dominance is excluded, although bisexual ascospores sometimes occur (cf. Lindegren, 1934). According to the descriptions given by Lindegren (1936), certain characters may be epistatic and others hypostatic. The three factor pairs  $Aa$ ,  $Ww$ , and  $Pp$ , which were studied in this investigation, demonstrate that the normal development of an organism depends upon the interaction of many genetic factors. The effect of these genes upon growth may be considered first. In a monocaryotic mycelium factors  $P$  and  $p$  are hypostatic to factors  $W$  and  $w$ , as may be seen from the following evidence: In the presence of  $W$  factor  $P$  produces the normal type of growth (the normal orange type,  $aWP$ ,

and the normal pale type,  $AWP$ ), while  $p$  conditions a very vigorous and fluffy type of mycelial growth (the fluffy orange type,  $aWp$ , and the fluffy albino type,  $AWp$ ). In strains carrying factor  $w$ , however, a dwarf type of monocaryotic mycelium is produced in the presence of either  $P$  or  $p$  (the light dwarf,  $Aw p$ , and the dark dwarf type,  $Aw P$ ). It is evident, therefore, that factors  $W$  or  $w$  determine whether the mycelium of a unisexual culture shall be vigorous or dwarf, while factors  $P$  or  $p$  produce modifications of these types. In a dicaryotic mycelium the factor pairs  $PP$  or  $Pp$  condition normal growth in the presence of  $WW$  or  $Ww$ , while the  $pp$  factor pair produces a fluffy growth.

The relationship of the three factor pairs to conidiospore color may now be considered. In the matings considered here  $A$  and  $w$  were absolutely linked, so that the effect of  $w$  upon conidiospore color could not be determined. It will be shown in the next discussion that when a cross-over does occur the resulting forms are a shade darker than the types discussed here. In an earlier paragraph it was mentioned that Dodge (1935a) and Tai (1936) found that a factor  $O$  for salmon orange conidia was strongly linked with the factor for Sex  $a$ . In interspecific hybrids this relationship was broken down so that many cross-overs were obtained (cf. Dodge, 1936). When studied by the method of ascus dissection, there was practically no possibility of misclassifying the distinctive types studied here. The linkage between  $a$  and  $O$  was very strong since no cross-over were obtained. As a consequence the symbol  $O$  has not been used in the formulae given in this paper. The normal orange unisexual type,  $aWP$ , and the fluffy orange type,  $aWp$ , have salmon orange conidiospore color due to the presence of factor  $a$ , regardless of the presence of  $P$  or  $p$ . Likewise, the normal pale unisexual type,  $AWP$ , the fluffy albino type,  $AWp$  (to be discussed in the following paper), the light dwarf,  $Aw p$ , and the dark dwarf,  $Aw P$ , have pale salmon conidiospore color, due to the presence of factor  $A$ , the  $P$  and  $p$  factors apparently having no effect. These factors play an important role in dicaryotic cultures, however, in that the salmon orange color characteristic of factor  $a$  was dominant over salmon pink in the presence of

*PP* or *Pp*, but an orange pink was produced when the factor pair *pp* was present.

In this experiment the color of the substratum was not due to one factor, such as *M* (cf. Tai, 1936), but to the interaction of two factor pairs, *Aa* and *Pp*. The following data indicate that *A* and *a* were hypostatic to *P*. In cultures in which factor *P* or the factor pairs *PP* or *Pp* were present, a chestnut brown color was found in the surface mycelium (normal orange type, *aWP*; normal pale type, *AWP*; dark dwarf type, *AwP*; and the normal bisexual type). The effect of *A* and *a* on the color of the substratum could be determined in cultures in which factor *p* was present. Since the fluffy orange type, *aWp*, with an orange colored substratum, and the fluffy albino type, *AWp*, with a colorless substratum, differ only in the *A* and *a* factors, the latter must be responsible for the color difference. When the *p* factor is homozygous, as in the semi-fertile type, the color of the substratum was intermediate (orange pink) between salmon orange and salmon pink.

The discussion thus far has shown that different genetic factors interact in the diploid cell to produce results not found in the haploid cell. While these results support the definition of the diploid cell as given by Buller (1941), it is necessary to explain how the factors in two separate nuclei may interact to produce different genetic phenomena. Judging from the experiments and hypotheses published thus far the most promising method of approach is from the chemical standpoint (cf. review by Goldschmidt, 1938).

While a number of chemical reactions have been studied in fungi (cf. review by Malloch, 1940), only the results obtained from the genus *Neurospora* will be mentioned here. As a result of chemical studies with *N. sitophila* it was shown that this species can form a number of different enzymes, which, with the exception of trehalse, are secreted in the culture solution. The production of these enzymes, however, was dependent upon the presence of specific compounds in the nutrient solution (cf. Went, 1901, a, b, c). In recent investigations by Beadle & Tatum (1941) X-rayed strains were tested for loss of synthetic abilities by transferring them to minimal media. A number of

mutants were obtained which were unable to synthesize specific chemical compounds, such as vitamin B<sub>1</sub>. Each of them differed from the control by a single gene, and each was made indistinguishable from normal by adding the specific substance that it could not synthesize. These facts were considered consistent with the assumption that each of the genes involved was concerned with the control of one and only one chemical reaction. Since chemical compounds are manufactured in the cell and secreted into the culture media there is no reason why these compounds should not react in the cytoplasm to produce intermediate effects such as the ones noted here. While this subject will be enlarged upon at another time, it is now necessary to turn to the consideration of other genetic phenomena.

Methods whereby genetic ratios may be produced in homothallic Ascomycetes have been illustrated by several diagrams. Since the cytological evidence indicates that the spindles can be arranged in either an oblique or longitudinal direction during the second division (cf. Dodge, 1927; Colson, 1934) it would suggest that after this division there would be a pair of sister nuclei in each end of the spore plasm all in one row. Dodge (1927), however, never found such an orientation of the reorganizing nuclei in *N. tetrasperma*. He assumes that a shifting in position must occur, so that a pair of nonsister nuclei will come to lie in each end of the ascus. Later (cf. Dodge, 1936), the longitudinal arrangement of the spindles was suggested as a possible explanation for certain types of segregation. It has been shown in the present paper that a 3 : 1 ratio can be obtained by either arrangement, but due to the wide divergence in the percentage of crossing-over necessary to explain this ratio by the two methods, it would appear that the two hypotheses are mutually exclusive. This would support the assumption that the spindles must shift their position before the ascospores are finally cut out. If we assume that the same percentage of crossing-over is present in both cases there are certain populations where both the oblique and longitudinal arrangements could occur (cf. Malloch, in press). Obviously, this is a subject which is of considerable importance to mycology, but its solution demands more critical evidence.



Dodge (1939) and Lindegren and Lindegren (1941) described new types which behaved like those due to chromosomal alterations. While evidence of chromosomal alterations was found in the progeny of culture No. 42, the types described in this report behaved like gene mutations. By growing  $F_2$  populations it was shown in a previous investigation (cf. Malloch, 1941) that bisexual X-rayed derivatives of *N. tetrasperma* are frequently heterozygous and that segregation of different characters may occur. Culture No. 42 is a strain which was heterozygous for two X-ray induced mutations, but stable types could be established in the third generation. In contrast to these results, many of the unisexual cultures were stable from the first generation. The previous conclusions (cf. loc. cit.) have been confirmed in that the association of certain characters may be due to a single factor, such as  $p$ , or to the linkage of two factors like  $A$  and  $w$ .

Evidence from several investigations suggests that increased vigor is found in some species of fungi following X-radiation. The fluffy orange and semi-fertile types, which were described in this paper are an illustration of this phenomenon. This increase in vegetative growth, however, may have been caused by the absence of the factors for normal perithecia and ascospore production.

#### SUMMARY

1. Eight character combinations, which were derived from one X-rayed ascospore of *Neurospora tetrasperma*, were analyzed in this investigation.

2. A genetic study of these characters indicated that the different types were governed by three pairs of factors,  $Aa$ ,  $Ww$ , and  $Pp$ . The factor pair  $Aa$  governs sex expression,  $A$  being associated with pale, and  $a$  with salmon-orange conidiospore color.  $W$  and  $w$  are factors affecting the form of hyphal growth,  $W$  being a dominant factor for normal, and  $w$  a recessive factor for a dwarf type of growth.  $W$  is strongly linked to  $a$  and  $w$  to  $A$ . The factor pair  $Pp$  governs perithecia development,  $P$  being associated with normal perithecia and ascospore production, and  $p$  with reduced perithecia and ascospore development.

3. Different genetic combinations are produced by various interactions between these factors.

4. The X-ray induced alterations studied in this investigation behave like gene mutations. The instability of such characters which has been noted in other organisms, was not a prominent feature of the genes discussed here.

5. The segregation of genetic factors in *N. tetrasperma* is affected by the following phenomena: the inclusion of non-sister nuclei by the cell wall during ascospore formation, the occurrence of crossing-over, the arrangement of the spindles during the second division and the orientation of the chromosomes with respect to the poles of the spindles during the second division. As a consequence of these conditions a culture, which was heterozygous for the three pairs of factors noted above, segregated into a ratio of 3 normal to 1 semi-fertile culture.

6. The occurrence of unisexual ascospores in this species, which produces bisexual spores for the most part, furnishes a method for detecting the segregation of certain recessive characters.

7. *N. tetrasperma* should be a favorable organism with which to investigate the nature of chemical substances produced by different genes, since both the unisexual and bisexual types are available. Although conjugate nuclei may produce chemical substances which, by reacting in the cytoplasm, produce new compounds necessary for the development of certain organs, the production of the substances themselves must ultimately be controlled by genetic factors.

8. As evidenced by the increased vigor of certain cultures, X-radiation provides a method for the creation of valuable new strains of fungi.

In closing, the writer takes pleasure in expressing his appreciation to Professors T. H. Goodspeed, Lee Bonar and W. C. Snyder under whose direction this study was carried out and to Professor A. Davis who extended the privileges of the botany laboratories. The author wishes to express his thanks to Professor J. Neyman for advice in regard to the statistical methods used in this series of investigation and to Mrs. F. W. Malloch and Mr. W. G. Malloch for valuable assistance in

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## NOTES AND BRIEF ARTICLES

### MYCOLOGIA

Mycologia has closed another successful chapter. The volume for 1941 consisted of 717 pages. The articles have been carefully selected and the character of the work speaks for itself. The total receipts for the year were \$4696.93, almost exactly the same as that for the preceding year. The total expenditures for the year were \$3769.03, leaving an accumulated balance of \$1722.79. Of this \$1000, which had been accumulated from the sale of back sets and interest was added to the Endowment Fund. This brings our Endowment to \$8000, leaving an unexpended reserve of \$722.79.

While Mycologia is in an excellent financial condition up to the present time, we nevertheless face one of the most critical years in our history, owing to the fact that the war has cut off most of our income from European and Asiatic countries, at least for the time being. This loss is estimated at \$700 or more. While we have sufficient reserve to cover this loss for the present, it will not continue to do so and we must look for new blood in our own country if we wish to maintain our activities at their present pace.

Last year a membership committee was appointed of which the writer was asked to serve as Chairman. This committee was active during the year and secured a considerable number of new members. At the last meeting in Dallas the committee was continued, and a strenuous campaign will be conducted through the present year to still further increase our memberships, and each member of the Society is hereby requested to consider himself a committee of one to help in this enterprise.—FRED J. SEAVER.

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### REVIEW

Degelius, Gunnar. Contributions to the Lichen Flora of North America. II. The Lichen Flora of the Great Smoky Mountains. Arkiv för Botanik 30 A: 1-80. 7 figures and 2 plates. 1941.

This is the second in a series of studies of the lichen flora of North America by the same author. The area involved is that limited by the boundaries of the Great Smoky Mountains National Park.

In discussing general composition and vertical distribution, the author points out that though the lichen flora of the area is rather poor, the lichen vegetation is rich. However, the list of 206 species, a few of which have not been definitely determined, includes some extremely interesting finds.

The following 15 new species are described: *Staurothle tenuissima* Degel., *Microthelia inops* Degel., *Pleurotrema solivagum* Degel., *Arthonia bisectata* Degel., *Lecidia Degelii* H. Magn., *L. deminutula* H. Magn., *L. gyrodes* H. Magn., *L. subtilis* Degel., *Rhizocarpon intermedium* Degel., *Stereocaulon tennesseense* H. Magn., *Lecanora (Aspicilia) olivaceopallida* H. Magn., *L. insignis* Degel., *Parmelia lobulifera* Degel., *Physcia subtilis* Degel., and *Anaptychia squamulosa* Degel. In addition, three new varieties: *Lecidea helvola* (Korb.) Th. Fr. v. *longispora* Degel., *L. olivacea* (Hoffm.) Mass. v. *inspersa* Degel., *Parmelia sorocheila* Vain. v. *catawbiensis* Degel., and one new form: *Umbilicaria papulosa* (Ach.) Nyl. f. *lacerata* Degel., are described. *Pleurotrema solivagum* Degel. represents a family new to North America, the chiefly tropical Paratheliaceae.

Seven species found in the Great Smoky Mountains have not been previously reported from North America: *Arthopyrenia pini-cola*, *Leptoraphis quercus*, *Catinaria albocincta*, *Ochrolechia Yasudae*, *Arthonia caesia*, *Parmelia dissecta*, and *Physcia Wainioi*. *Erioderma* is a genus new to North America; one species is reported, *E. mollissimum*. Six species have not been reported previously from the United States: *Pyrenula bahiana*, *P. brunnea*, *Parmelia sorocheila*, *Physcia melops*, *Anaptychia corallophora*, and *A. sorediifera*.

The author lists a number of species, found within the Great Smoky Mountains National Park, which have been hitherto reported from a limited number of points in the United States or from entirely different parts of the country. This list, of interest from a phyto-geographic standpoint, includes: *Arthopyrenia fallax*, *Leptoraphis contorta*, *Opegraphia cinerea*, *Crocynia neglecta*, *Ther-*

*mutis velutina*, *Pyrenopsis subfuliginosa*, *Leptogium americanum*, *Pseudocyphellaria Mougeotiana*, *Nephroma parile*, *Lecidea granulosa*, *L. helvola*, *L. mollis*, *L. subsimplex*, *Bacidia chlorantha*, *B. endocyanea*, *Rhizocarpon plicatile*, *Rh. reductum*, *Cladonia implexa*, *Cl. mitis*, *Stereocaulon pileatum*, *Pertusaria amara*, *P. laevigata*, *P. leioterella*, *Lecanora hypoptoides*, *L. pinastri*, *Parmelia Arnoldii*, *P. cetrarioides*, *P. revoluta*, *P. subaurifera*, *P. trichotera*, *P. tubulosa*, *Cetraria ciliaris*, *Alectoria altaica*, *A. bicolor*, and *A. sarmentosa*.

Though lacking in illustrative material, this paper is a valuable contribution to knowledge of the lichen flora of North America.—S. L. MEYER.

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## MYCOLOGICAL SOCIETY OF AMERICA

### REPORT OF THE 1941 FORAY

(WITH 1 FIGURE)

The 1941 Summer Foray of the Mycological Society of America was held at Macdonald College, Quebec, August 25–28. The local arrangements were made by Dr. Ivan H. Crowell of the Department of Plant Pathology at the College and Mr. Henry A. C. Jackson of Montreal, who planned a well-organized Foray and provided every convenience that was possible or desired. The College opened the women's dormitory and dining-room for the use of the group. Such an arrangement is always an excellent feature because it makes for greater sociability and allows more contact for profitable discussion. The well-equipped Plant Pathology laboratory provided every facility for an event of this kind.

Forty-one people in all attended. Twenty-two of these were mycologists and the remainder wives and children or other visitors. Unfortunately, only five members of the Society from the United States were able to attend, in all probability largely because of the ill-timed agitation about the gas shortage just prior to the time for starting for the Foray. M. Dr. Georges Maheux, Provincial Entomologist of the Department of Agriculture, was the official representative of the Province of Quebec.

Excellent collecting grounds had been selected at Morgan's Woods near the College and on Île Jesus and Île Perrot by Messrs. Crowell and Jackson, with the assistance of Messrs. William Brown and Henry Mousley, ornithological friends of Mr. Jackson. The collecting was fair but not as good as it should have been for these



1941 FORAY AT MACDONALD COLLEGE, QUEBEC.  
PHOTOGRAPH BY MAURICE B. WALTERS.

localities on account of the prevailing dry weather following adequate rain some time before.

On Tuesday afternoon, Mrs. Crowell entertained the ladies at tea.

On Tuesday evening in one of the laboratories there was an exhibit of the superb water-color drawings of fungi by Henry A. C. Jackson and of excellent colored photographs of fungi by Maurice B. Walters.

On Wednesday evening there was a business meeting with the Vice President of the Society presiding and with Dr. Crowell



acting as Secretary of the meeting. The following resolutions were passed: the thanks of the Society to Dean W. H. Brittain of Macdonald College for his invitation to hold the Foray at this institution; commendation of Messrs. Crowell, Jackson, Brown and Mousley for their efforts in making the Foray a success; thanks to Miss Geneva Jackson for her drawing of the serio-comic sketch-map of the approaches to the College and of the collecting grounds; sympathy to Dr. Dearnness in his recent bereavement; expression of regrets to Messrs. Overholts, Whetzel and Beardslee, quite regular attendants at past Forays, at their inability to attend this year. It was voted to publish a complete list of the fungi collected, to be compiled by the Vice President as soon as the several lists may be completed. There was discussion of the place for the next Foray, which in general was heartily in favor of accepting an invitation from Dr. Bessey to go to Michigan should his invitation of this year be repeated.

After the business meeting, in the Stewart room of the dormitory the group was entertained by M. Dr. Maheux and Dr. Groves—the former with his songs in French at the piano and in leading songs participated in by the whole group as only he can entertain, and by the latter with very artistic renditions at the piano.

On Thursday afternoon the entire group drove to the Botanical Garden of the University of Montreal and participated in an event of great interest to all those present—the dedication of the John Dearnness Laboratory of Plant Pathology to the first and foremost Canadian mycologist and the beloved friend of all American mycologists. The ceremonies were opened by an address by Fr. Marie-Victorin, the eminent Canadian taxonomist, who outlined the purpose of the occasion and extolled the attainments of Dr. Dearnness. Dr. Dearnness then responded in his very original manner in a most pleasing way, with a brief history of the development of mycology, its relation to other botanical sciences and its value as a hobby and intellectual stimulus, without, however, failing to pay entertaining attention to the children present. The Vice President responded for the Society and for American botanists in general in commending the authorities of the Botanical Garden for their graciousness in thus honoring Dr. Dearnness and in congratu-

lating him as so highly deserving of such an honor. Following these ceremonies the group was conducted upon an inspection tour of the building and finally to the Laboratory of Plant Pathology, where Dr. Dearness was handed the key to open it officially. Then the group proceeded to the Garden restaurant to enjoy refreshments, with Mm. Drs. Brunel and Jacques as hosts.—  
WALTER H. SNELL, VICE PRESIDENT.

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### PHYTOPATHOLOGICAL CLASSICS

A new Phytopathological Classic No. 7 is now available. This consists of four classical papers on virus diseases translated from the German by Dr. James Johnson of the University of Wisconsin. These papers are:

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by Dmitrii Ivanowski, 1892.
3. **Concerning a contagium vivum fluidum as a cause of the spot-disease of tobacco leaves**  
by Martinus W. Beijerinck, 1898.
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### INDEX TO MYCOLOGIA EUROPAEA

The Farlow Library has published a small edition of an Index to Mycologia Europaea by C. H. Persoon (1822-28). The Index was compiled by Dr. and Mrs. Donald P. Rogers, and it lists alphabetically all fungus names and the volumes and pages where

they occur. In case a name was used as a synonym the page reference has been printed in italics.

Because until now it lacked an index this important contribution to mycological taxonomy has been hard to use and therefore often ignored.

A copy of this useful Index will be sent to all who are on the regular exchange list of the Farlow Library. The few remaining copies may be purchased by interested individuals and institutions for twenty-five cents each.—EDGAR V. SEELER, JR.





**E. A. BESSEY, PRESIDENT 1941**





# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

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No. 4

## SOME PROBLEMS IN FUNGUS PHYLOGENY

ERNST A. BESSEY<sup>1</sup>

(WITH 5 FIGURES)

Owing to the nature of fungi their fossil remains are mostly limited to hyphae in fossilized wood and to the remains of pycnidia or perithecia in leaves or stems, with a few records of woody sporophores of polypores. These do not reveal much that is of help in phylogenetic studies, except to show us that higher fungi existed as parasites and saprophytes millions of years ago. Failing palaeontological records recourse must then be had to the other resources of the phylogeneticist: comparative morphology and ontogeny, and serum diagnostic studies.

Comparison of the morphology of now existing species is useful on the theory that evolution may result in divergences so that the more nearly related species will be those with the greatest similarities and, conversely, those that are less similar will represent greater evolutionary modifications and hence more distant relationship. This is probably true in the main, but there are many opportunities for error. It must be borne in mind that sometimes a single gene difference may produce a very great effect. Some dwarf plants, *e.g.* the Cupid sweet pea, appear to have arisen from large plants by this method and yet the difference is so striking that we would be inclined to consider the organisms as quite distantly related. So we may, on the basis of comparative morphology, erect a scheme of ascent or descent in which because of some

<sup>1</sup> Address of the Retiring President of the Mycological Society of America, December 30, 1941, at the Dallas meeting of the American Association for the Advancement of Science.

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such marked difference we may place two organisms far apart when perhaps they are really very closely related. The duplication of chromosomes, polyploidy, may also mislead us.

Another source of error is the frequently arising impossibility within a group of related organisms of deciding which characters are the more primitive and which the more advanced. In the Erysiphaceae the genera *Podosphaera* and *Sphaerotheca* produce but a single ascus in each perithecium, but in the very similar *Microsphaera* and *Erysiphe* respectively the asci are several to many, as is true of the other genera of the family. Upon examination of the closely related Meliolaceae and the less closely related Aspergillales we find that these are practically all polyascous so that we may safely conclude that the monascous condition in the Erysiphaceae is derived. Yet this does not grant us the right to conclude that this is necessarily true for the Ascomyceteae as a whole, even though, for other reasons, the speaker believes that the Saccharomycetales, which are monascous, are not primitively so but through reduction from groups with numerous asci. It is apparent therefore that the student of fungus phylogeny must know thoroughly not only the special group he is studying but all other groups that are possibly more or less closely related.

We cannot deny the possibility of convergent evolution. As an example take *Olpidiopsis* and *Pseudolpidiopsis* from the group formerly called the Chytridiales. Both arise from naked zoöspores which penetrate the host cells and enlarge there, sooner or later forming a cell wall. Two such adjacent cells may fuse, the contents of the one entering the other. Eventually zoöspores are produced which escape through an exit tube. Yet in *Olpidiopsis* the zoöspores are anteriorly biflagellate and the cell wall gives the cellulose reaction with chloriodide of zinc while in *Pseudolpidiopsis* the zoöspores are posteriorly uniflagellate and chloriodide of zinc does not call forth the cellulose reaction. We might conclude that these are very closely related organisms which have undergone relatively minor mutations as to flagellar number or that they represent converging branches of widely different groups of not closely related organisms. Another example, which clearly does not indicate close relationship, is *Tremellodon*, of the Order Tremellales, whose fruiting body bears its hymenium on teeth after the manner of

some species of *Hydnum*, one of the Eubasidiaceae. Here the differences in basidium structure and comparison with related forms make it certain that the similarity of the sporophores of the two organisms is pure convergence.

Carl Mez (20) has attempted to measure the degree of relationship by serum diagnosis methods. These are based on the theory that the genes are nucleoprotein units and that the more of the genes that are identical, *i.e.* the more closely related the organisms are, the greater will be the reaction. Thus the greater the precipitation produced in an animal serum sensitized by a given species of plant when nucleoprotein solutions from another plant are added, the greater the degree of relationship. The studies of Mez and his students have shown great correlation between the conclusions drawn from this method of study and the relationships assumed as a result of morphological studies. Yet in some instances the two methods have led to very divergent conclusions. How far may we trust either? Where both methods agree shall we say that one confirms the other? In that case which shall we consider the more trustworthy, the nucleoprotein reaction or the conclusion drawn from the actually visible results of the interactions of these proteins (genes)? Can we with fairness accept the confirmation of our phylogenetic scheme by serum diagnostic methods when they agree and reject them when they do not agree with our scheme as we have worked it out on the basis of comparative morphology, aided perhaps by our unrecognized preconceived ideas?

All of the foregoing reveals some of the mazes and pitfalls that lie before one when he attempts by one method or another or by a combination of methods to judge of relationships and of the probable course of evolution in so great a group of exceedingly varied organisms as the fungi.

In the following pages are discussed a few only of the many problems of fungus phylogeny. An attempt will be made to approach each problem from its various viewpoints without endeavoring to claim that the final solution has been reached.

The first problem is that of Slime Molds and their probable or possible allies. The organisms to be discussed have in common the fact that the encysted stage is the spore, the whole vegetative life cycle consisting of the naked amoeboid or plasmodial stages.

The true Slime Molds (Myxomycetes or Myxogastres of various authors, not in all cases with the same limits) and the Plasmodiophoraceae produce spores which possess cell walls of more or less disputed composition. Upon germination they set free usually one, sometimes more, naked, anteriorly flagellate cells more or less endowed with the ability to change their form in an amoeboid manner and to ingest solid food. The flagella are single or two in number. In the Plasmodiophoraceae they are always two and unequal in length. In the Slime Molds, proper, more frequently the flagellum is single, and anterior, but Gilbert (12) and later Sinoto and Yuasa (27, 34) have shown that occasionally anteriorly biflagellate, but uninucleate cells are produced. These are not similar to the biflagellate zoöspores studied by Cotner in *Blastocladia*, which are binucleate and represent two cells that have failed to separate into the normal uninucleate, uniflagellate cells. In the biflagellate swarm cells of the Slime Molds the flagella may be equal or unequal, each flagellum arising from a minute granule just within the surface of the plasma membrane. In the uniflagellate cells which make up the majority of the swarm cells these two granules are present but from only one of them does a flagellum arise. From these circumstances it seems logical to assume that the ancestors of both these groups possessed anteriorly biflagellate swarm cells and that the Slime Molds have progressed further than the Plasmodiophoraceae toward the complete loss of one flagellum.

The Acrasiales and Labyrinthulales resemble the two foregoing groups in being naked except as to their spores. The latter, however, give rise to naked amoeboid cells without any flagellum in the Acrasiales, and in one genus of the Labyrinthulales, another genus of this latter group, *Labyrinthomyxa*, possessing one anterior flagellum. These naked cells are myxamoebae, like these into which the flagellate swarm cells of the two preceding groups become transformed. In the Acrasiales these naked myxamoebae draw together into easily separating masses or pseudoplasmodia, which, according to Skupienski (28), become true plasmodia in some cases. In the Labyrinthulales these myxamoebae join but become pushed apart by slender, thread like extensions forming a so-called net plasmodium with large lacunae. These cells divide by fission and draw apart with a connecting process. Eventually all

may round up and encyst, forming spores. Whether or not a sexual stage occurs has not been determined.

Apparently the ancestral forms were aquatic, naked, more or less amoeboid organisms with two anterior flagella and, like most naked Protozoa, with the power of encysting to survive unfavorable environments. Probably they easily united into plasmodial masses. The Acrasiales and the true Slime Molds have emerged to become aerial organisms, at least as to their fruiting structures, thus permitting aerial distribution of their spores. Connected with this is the production of the characteristic, often stalked sporangia with structures for support and for setting free the spores (stipe, columella, capillitium, peridium, etc.). These structures are lacking in the internally parasitic Plasmodiophorales and Labyrinthulales. Quite similar to the foregoing groups is the genus *Pseudospora* of Cienkowski. A zoospore infects a host cell (usually of an alga) and develops into a plasmodium containing numerous nuclei. Eventually this breaks up into numerous naked, uninucleate, anteriorly uniflagellate more or less amoeboid, swarm cells which infect other host cells and thus complete the life cycle. Under certain conditions the whole plasmodium encysts but not the individual swarm cells. With the same life history is *Barbetia* of Dangeard (sometimes included in *Pseudospora*) in which the swarm cells are anteriorly biflagellate. These two genera are usually considered to be either pseudopodial Flagellata or flagellate *Rhizopoda*.

From their life history and structure it seemed logical to the great mycologist Anton de Bary (3), sixty years ago, to conclude that these groups of naked-bodied organisms, the Slime Molds and Plasmodiophorales, are not at all closely related to plants but that they are true animals. It must be noted that protozoölogists like Calkins (7), Kudo (14) and Minchin (21) include them in the group of Protozoa among the Sarcodina. Minchin classifies them as Phylum Protozoa, Class Sarcodina, Order Mycetozoa, dividing this order into Sub-order Euplasmodida (including the true Slime Molds) and Sub-order Sorophora (the Acrasiales), with *Labyrinthula* and *Plasmodiophora* as a closely related appendix but not definitely assigned to either sub-order. Kudo also places the Slime

Molds, and the other groups, along with *Pseudospora*, close together in the Sarcodina.

Some protozoölogists derive the Flagellata from Rhizopoda, regarding the flagella as especially modified pseudopodia. Others believe that the Flagellata are the more primitive, and that those

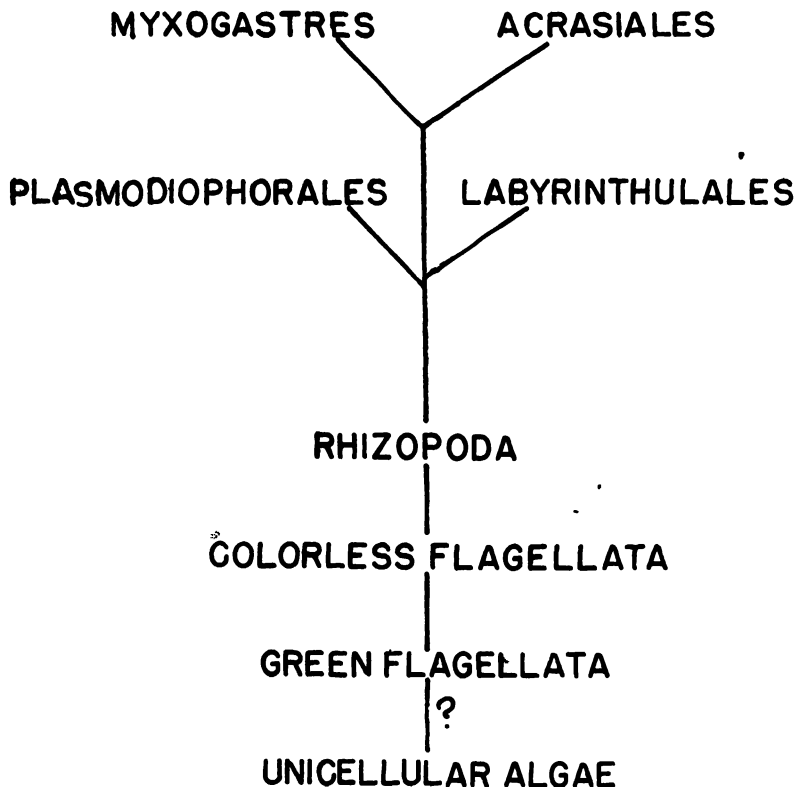


FIG. 1. Suggested phylogeny of Mycetozoa.

of this group that are amoeboid are more advanced on their way to the Rhizopoda with flagella and thence to those Rhizopoda lacking flagella. Carl Mez (20) has suggested that the chlorophyll-bearing Flagellata are derived from algae whose naked swarm-cell stage has become the predominant vegetative stage, the encysted stage being limited to the survival of unfavorable conditions. In the accompanying diagram (FIG. 1) this possible origin of the Flagellata and of the Mycetozoa is shown.

Turning away from the Animal Kingdom let us consider some organisms accepted by botanists as fungi, even though G. W. Martin (19) does not consider the fungi to be, properly, plants, but a third kingdom parallel to animals and plants and arising together with these in a common ancestral group of very simple organisms. Concerning the phylogeny of the organisms until recently included in the single order Chytridiales we find many conflicting ideas. Like the Mycetozoa the organisms of this group also possess a stage consisting of naked flagellate cells which may even show the ability to change their shape in an amoeboid manner. It is doubtful, however, whether they actually ingest particles of food as do the naked cells of the Slime Molds. The Chytridial swarm cells eventually encyst, externally to or within the substratum, and enlarge, becoming multinucleate and forming a sporangium directly or dividing into several sporangia. From these arise the swarm cells. Various types of sexuality are known, chiefly the union of two swarm cells or of two adjacent organisms.

In this group the zoöspores escape by the softening of the tip of an exit tube or papilla or by the formation of an operculum. This difference is being made use of in generic and family distinction by the more recent students of the group. The structure of the swarm cells, particularly the number, structure and location of the flagella is coming more and more to the fore in the systems of classification of these organisms. In the majority of the genera there is a single posterior flagellum of the whip-lash type, with no lateral tinsels. These form the Order Chytridiales in the narrower sense. Two or three genera, *e.g.* *Rhizidiomyces*, possess only one flagellum, and that in the anterior position. Couch (8) has shown this to be of the tinsel type. Usually also included in this order is the family Olpidiopsidaceae (formerly called the Woroninaceae, a name that may have to be abandoned if the genus *Woronina* is transferred to the Plasmodiophoraceae, as has been suggested). In this family the swarm cells have two flagella, at the anterior end of the cell or somewhat lateral. They are equal or one is somewhat longer, in that case always the anterior one if they are laterally attached. This flagellum is, according to Couch, of the tinsel type, the other being of the whip-lash type.

Correlated with the differences between one posterior and two anterior flagella are differences in the cell wall composition. In the Olpidiopsidaceae the cell wall responds immediately with the typical

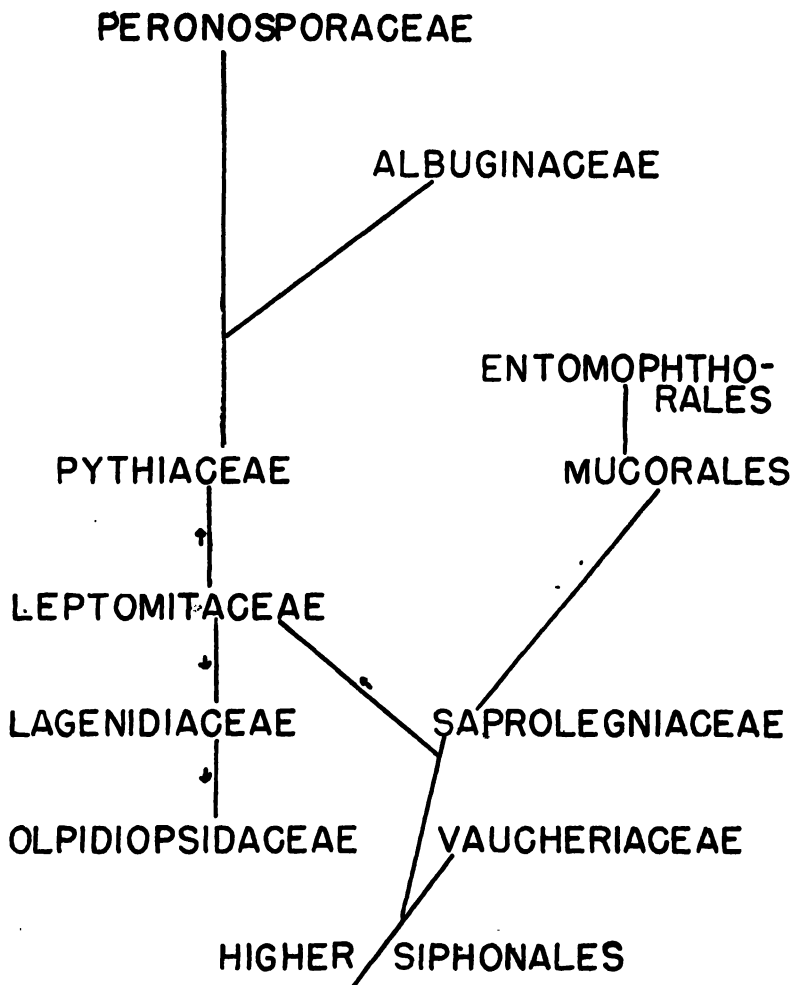


FIG. 2. Phylogeny of the biflagellate Phycomycetes, based upon Sachs' and Mez's idea of the origin of the Saprolegniales from the Siphonales.

cellulose reaction upon the application of chloriodide of zinc solution while those producing swarm cells with a single posterior flagellum usually do not respond to this test. *Olpidium radicale*, according to Schwartz and Cook (26), and the walls of the spo-

rangial sorus of some of the Synchroniaceae, according to Scherffel (25), are an exception and do show the cellulose reaction.

There are no clearly marked differences in the modes of sexual reproduction that can be definitely correlated with these swarm cell differences. In some genera, *e.g.* *Synchytrium* and *Olpidium*, equal swarm spores may unite by two's, the resulting zygote producing upon growth and development a thick walled sporangium or sorus of sporangia. For *Pseudolpidiopsis* and *Olpidiopsis* the method of sexual reproduction has already been described. In *Polyphagus euglenae*, in *Rhizophidium graminis*, according to Ledingham (15), and in *Diplophlyctis intestina*, according to Sparrow (30), the gamete nucleus is carried through a rhizoid to another organism of the same species.

Historically the Chytridiales in the broader sense have been treated very variously by the different students of the classification and phylogeny of fungi. Sachs (23) did not mention the group in the 1874 edition of his Lehrbuch but in 1882, in Vines' translation (24) they are grouped with the Protococcoideae in line with Sachs' idea that the fungi represented side-shoots, that had lost their chlorophyll, from algae at different levels of evolution. In 1884 Anton de Bary (3) suggested that they might have arisen by degeneration or simplification of Mucorineae or Ancylistineae, to use his names, down through the Rhizidiae and Olpidiae to the Synchroniae, or possibly that they had evolved by the loss of chlorophyll from unicellular algae, *e.g.* *Characium*, *Chlorochytrium*, etc., of the Protococcaceae. In the latter case if the Chytridineae are monophyletic the Mucorineae and Ancylistineae were probably descended from them. Possibly, he suggested, the Rhizidiae descended from these higher groups and the Olpidiae and Synchroniae came from the unicellular algae.

In 1901 Dangeard (9) suggested that the "Chytridinées" were descended from zoöspore-producing "Monadinées à nutrition animale" and that these are connected with *Vampyrella*. The latter is usually placed in the Rhizopoda. He believed that the chlorophyllless Protozoa, especially various groups of the Flagellata, are the source of several lines of evolution leading to plants by the acquisition of chlorophyll and the loss of the animal type of nutrition. The possibility of evolution in the opposite direction from



the lower plants to the one-celled animals he rejects as totally impossible. Nearly forty years ago Charles E. Bessey (4) strongly influenced by the ideas of Sachs, suggested that those organisms of this group which live internally in their host cells were derived from unicellular green algae, the Protococcoideae. On the other hand the "Chytridiaceae," that live externally on the host cell, obtaining their nourishment by rhizoids, he suggested might be derived from the neighborhood of *Botrydium* (one of the heterocont algae or Xanthophyceae). With our increased knowledge of the Chytrids it is clear that these suggestions need to be greatly revised, if accepted at all.

Atkinson (1) in 1909 wavered between the possibility that the Chytridiales had arisen from Protococcales that had lost their chlorophyll or that Dangeard's suggestion of their origin from the Monads might be correct. His studies of *Rhodochytrium*, which he considered an alga that rather recently had undergone loss of chlorophyll, made him not unfavorable to the idea of the algal origin of the whole Chytrid group. He, at that time, did not believe that the number or positions of the flagella on the swarm cells were of fundamental phylogenetic importance.

Mez (20), in 1929, in his discussion of the relationships of the fungi, as determined principally by the serum reaction method, made extrapolations for the Chytridiales, and other possibly related organisms which are too small or difficultly obtainable in sufficient quantity to permit of study by that method. He suggested that by parallel lines of reduction the Ancylistidaceae and Lagenidiaceae had arisen from the Saprolegniaceae and that from the Lagenidiaceae by further reduction had developed the Woroniaceae (Olpidiopsidaceae). The similarity in structure of these latter to the Olpidiaceae he considered to be due to convergence, the single posterior flagellum of the latter militating against the idea that they are related to the Woroniaceae with two anterior flagella. The Oöchytriaceae, Cladochytriaceae and Rhizidiaceae and thence the Olpidiaceae, he considered as a progressively simplified series arising in the neighborhood of the Monoblepharidales. This latter group he believed to have arisen, together with the Saprolegniales, from the Siphonales, the Saprolegniales from near *Vaucheria* and the Monoblepharidales from further down the line,

not far from *Codium*. In the Saprolegniales the anteriorly bi-flagellate structure of the swarm cells is retained, one flagellum, with a consequent reversal of position on the cell, being charac-

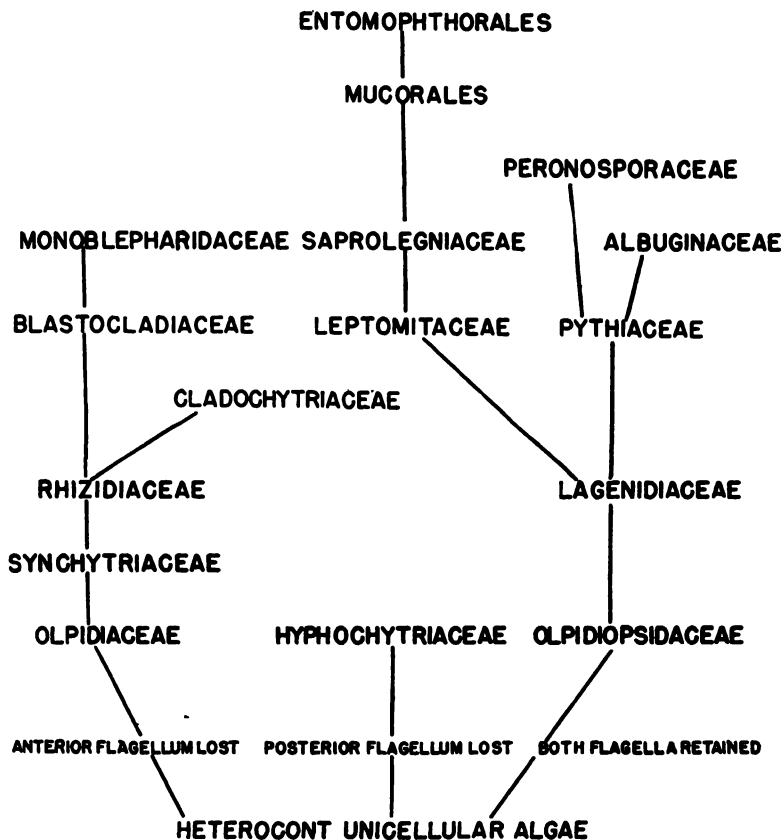


FIG. 3. Suggested phylogeny of the Phycomycetes based upon the idea of their origin from unicellular algae.

teristic of the Monoblepharidales. The serum precipitation reaction is very strong between the Saprolegniales and *Vaucheria*.

It seems pretty well agreed now (Sparrow (29), Weston (33), and others) that the posteriorly uniflagellate Phycomycetes form a continuous phylogenetic series. These would contain the four groups, which Sparrow breaks up into many families, of Olpidiaceae, Synchronytriaceae, Rhizidiaceae and Cladochytriaceae, which for

Fitzpatrick made up the bulk of the Chytridiales, and the Monoblepharidales as delimited by Sparrow in 1933. The first three are monocentric, *i.e.* from the swarm cell arises a uninucleate cell which enlarges, becomes multinucleate and then becomes directly a sporangium or, in Synchytriaceae, a sorus of sporangia. In the Cladochytriaceae the organism is monocentric at first but by the passage of a nucleus through a modified rhizoid (rhizomycelium of Karling) to an enlarged portion of the latter it becomes polycentric, each center becoming a sporangium or budding off a cell or cells which become sporangia. In the Monoblepharidales we have coenocytic organisms varying from the clavate *Blastocladiella* which bears at its apex a single sporangium or gametangium to the larger filamentous forms like *Blastocladia*, *Allomyces* and *Monoblepharis* which are coenocytes and respectively isoplanogametic, heteroplanogametic and reproducing by fertilization of a non-flagellate egg by a uniflagellate sperm. The egg in some species of *Monoblepharis* is more or less motile though lacking a flagellum. The main gap in the whole series is between the unicellular, uninucleate Rhizidiaceae and the multinucleate, coenocytic *Blastocladiella*. In the former practically the whole contents of the single cell, after nuclear division, followed by cleavage of the cytoplasm, become the mass of swarm cells while in the latter the multinucleate clavate plant body gives rise at its apex to a single sporangium (or gametangium) whose contents become the swarm cells. Perhaps a step toward the latter is seen in those Chytrids which leave a little bit of nucleated cytoplasm in the base of the sporangium, from which a new sporangium may be formed. Possibly the basal vesicle of *Phlyctochytrium* may have been the initial point for the evolution of the vegetative base from which arises the sporangium in *Blastocladiella*.

It is of course easy to conceive of a reduction from some more filamentous form of the isoplanogametic *Blastocladia* through *Blastocladiella* to the Rhizidiaceae and other posteriorly uniflagellate Chytridiales and in the other direction to the closely related, heteroplanogametic *Allomyces* and to *Monoblepharis*. We must then find an origin for *Blastocladia*. To derive *Monoblepharis* from the alga *Oedogonium* seems far-fetched. The latter is truly cellular, with uninucleate cells and the zoöspores and sperms are

stephanocont, *i.e.*, have a wreath of cilia near the anterior end. *Monoblepharis* is coenocytic, not cellular, and the zoöspores and sperms are posteriorly uniflagellate. The cell wall composition and structure are different also.

The groups with biflagellate swarm cells: Olpidiopsidaceae, Lagenidiaceae, Leptomitaceae, Saprolegniaceae, and the three

IN THESE THREE GROUPS OCCUR FORMS WITH

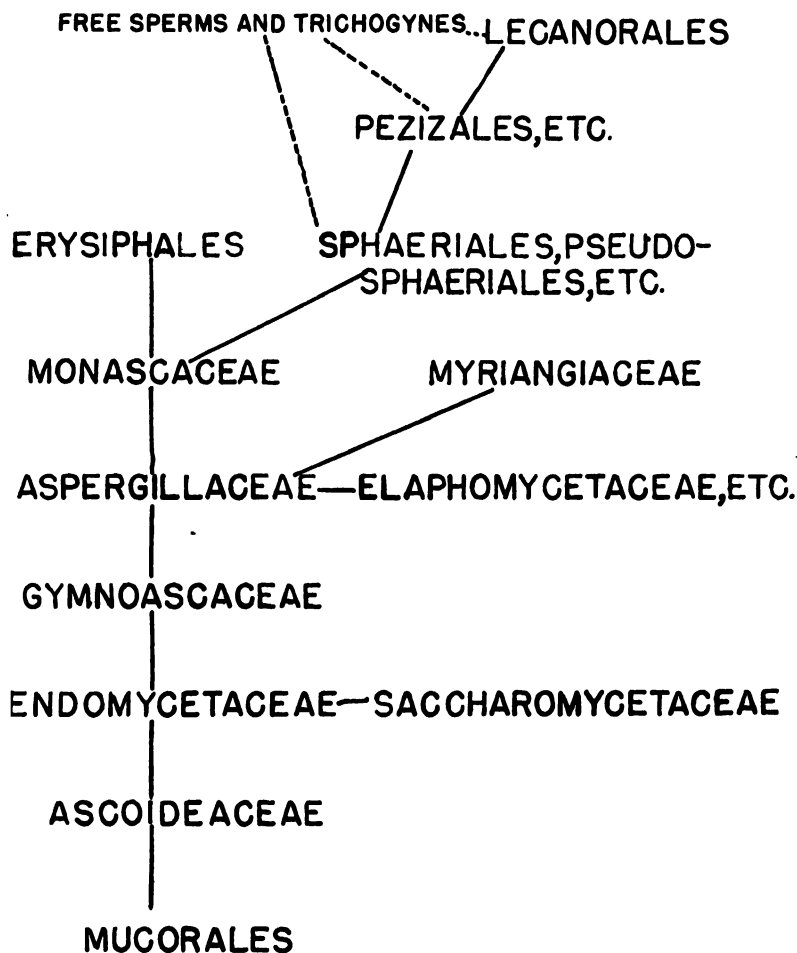


FIG. 4. Phylogeny of the Ascomycetes following in the main Dangeard, Atkinson, Gäumann and Mez.

families composing the Peronosporales also form a rather continuous series. In the first-named family the life history and general morphology are close to those of some of the Olpidiaceae but the swarm cells of the latter are posteriorly uniflagellate. Furthermore in the Olpidiopsidaceae the cell wall shows an immediate response characteristic of cellulose on application of the iodine-containing cellulose tests, while this reaction is slow or lacking in the *Olpidiaceae*, *Olpidium radicale* being an exception. Sexual reproduction in *Olpidiopsis* resembles that in *Pseudolpidiopsis*, being the union within the host cell of two adjacent uninucleate fungus cells, the contents of the one passing into the other, the latter after a longer or shorter resting period becoming the sporangium. In the Lagenidiaceae a short coenocytic mycelium, often limited to one but sometimes extending to several host cells, divides into short segments each of which becomes a sporangium, emptying by an exit tube, or a gametangium. The latter may be an oögone with a single egg, in some cases at least with periplasm, or an antherid whose contents enter the oögone through a conjugation tube. In the Leptomitaceae, Saprolegniaceae and the Peronosporales, the coenocytic mycelium is very much more extensive (except in some alga-inhabiting species of *Pythium*) and bears terminally on the main or lateral hyphae the sporangia and gametangia. This series of families is rather close, without great gaps, and may be read from the Olpidiopsidaceae upward through the Lagenidiaceae to the Leptomitaceae and Saprolegniaceae and to the Peronosporaceae. On the other hand the evidence is just as strong that the Lagenidiaceae are an intermediate step in the downward evolution to the Olpidiopsidaceae. Long ago Sachs (23) suggested that *Vaucheria* among the Siphonales was probably close to the algal form from which the Saprolegniales arose. If the observation of Apinis was correct that in the genus *Archilegnia* are produced flagellate sperm cells which enter the oögone through definite openings this shows still greater similarity between the alga mentioned and the Saprolegniales. Mez's serum reaction experiments reveal a very strong reaction between *Vaucheria* and *Saprolegnia*. The fact that the species of the genus *Woronina* are all parasites in the filaments of Saprolegniaceae except one, and that this species parasitizes in *Vaucheria* has been adduced as a further



the single flagellum (anterior in position) being of the tinsel type and the second, when present, of the whip-lash type and directed posteriorly. In the Euglenophyta the one or two flagella are of the tinsel type only, while in some of the colorless Flagellata the flagella, whether 1, 2, 4, 6 or 8, are all of the whip-lash type except in the Oicomonadaceae in which the single flagellum is of the tinsel type. Unfortunately for our speculations he has published no reports on the type of flagella in the Siphonales.

I am therefore tempted to suggest that from a group of one-celled Heterocont algae, by the loss of chlorophyll, as in some of the species of *Harpochytrium*, there arose a parasitic series, the Chytridiales in the broader use of the term, and that those that retained both flagella led to the Olpidiopsidaceae, those that lost the posterior, whip-lash flagellum led to *Rhizidiomyces* and its relatives, and that by loss of the anterior, tinsel-type flagellum arose the whole *Olpidium* to *Monoblepharis* series. If we could know whether the higher Siphonales have the two types of flagella (and some species of *Vaucheria* have unequal flagella) we would have greater faith that this group might well be the ancestral line of the Saprolegniales. If the two flagella should turn out to be both of the whip-lash type, as in the Ulotrichales, the alternate suggestion perhaps would have greater validity.

Figure 2 is a diagrammatic representation of the relationship in accordance with the ideas of Sachs and of Mez who derive the Saprolegniales from the Siphonales, near *Vaucheria*. In figure 3 is given a diagram showing how the Chytridiales might have arisen from unicellular algae.

The Mucorales have been tossed hither and yon by those seeking to connect them with lower Phycomyceteae. The fact that cellulose is concealed in many of them and that chitin seems to be present in the sporangiophores of some has led to the suggestion that they have arisen either from the Monoblepharidales (in the broader sense of the term) or from the Cladochytriaceae or their near relatives in which sexual reproduction is isogametic. I venture to suggest that they have arisen from soil Saprolegniales. In the first place the latter group contains many soil-inhabiting forms, as is true of the Mucorales. In the latter the young, rapidly growing mycelium often shows the presence of cellulose though the

cellulose reaction is usually masked by the presence of other substances in the older mycelium. In the Saprolegniaceae we find *Aplanes* in which the sporangium produces spores which lack flagella, a suggestion as to how the sporangia of the Mucorales may have arisen, with their non-motile spores. In *Dicranophora* the "zygospore" is the product of the union of a small, antherid-like gametangium with a large, oogone-like one. Even in those Mucorales where the gametangia are approximately equal in size the few cytological studies seem to show that the privileged nucleus (or nuclei) from one gametangium passes through a small opening into the other gametangium, after this occurring the complete dissolution of the septum separating the two.

Probably the Entomophthorales are close to the Mucorales, especially since the "conidia" of *Basidiobolus* have been shown by Miss Levisohn (18) to be sporangia which produce their spores only after having been ingested by frogs and other animals. Their sexual reproduction is not uniform but resembles somewhat that of various Mucorales. The Harpellaceae and Genistellaceae studied by Leger, Duboscq and Gauthier (16, 17) and the various genera of parasites of amoebae and nematodes studied by Drechsler (10, 11) and comprising the family Zoöpagaceae possess types of sexual reproduction that have some similarity to those found in the Mucorales and Entomophthorales, and possibly are related to them, but their exact relationship can probably be revealed only by life-history and cytological studies. Possibly they have developed in a direction somewhat parallel to these two orders from forms with slender filaments in the neighborhood of the Pythiaceae.

The higher fungi are still a battleground for the proponents of various phylogenetic speculations. The old Brefeldian (6) theory that sexuality was entirely lacking in them has been completely refuted. This is true also of his idea that the ascus was an asexual structure homologous to and descended from the sporangium of the Phycomycetes while the basidium was a conidiophore with fixed number of conidia (four, in the majority of the Basidiomyceteae) and descended from the conidiophore of Phycomycetes. It is now rather generally agreed that the ascus and basidium are homologous structures and that the latter has been evolved from



the former. Accordingly, any speculation as to the phylogeny of the one group must perforce have reference to the phylogeny of the other.

Brefeld looked upon *Monascus* as a fungus containing a single, large, multispored ascus, enclosed by a peridium of hyphal structure. This, he surmised, was the equivalent of a stalkless sporangium of *Mortierella*, surrounded completely by the envelope of hyphae usually found at the base of the stalk. The fact that the ascocarp of *Monascus* contains many asci formed in much the same way as those of *Aspergillus* throws *Monascus* out as an intermediate step from the Phycomyceteae to the Ascomyceteae.

Dangeard (9) and Atkinson (2), and following them many other mycologists have suggested that the Ascoideaceae, especially *Dipodascus*, might well be an intermediate stage between the Mucorales and higher groups of the Ascomyceteae. In *Mucor* the union of two multinucleate gametangia produces a multinucleate zygospore from which after a resting period there arises a sporangio-phore bearing a large sporangium. Their suggestion is that there has been a telescoping of these two phenomena. In *Dipodascus albidus* the mycelium is composed of multinucleate (coenocytic) segments. From this mycelium, often from adjacent segments, arise two multinucleate gametangia which unite, with one privileged nucleus from each gametangium uniting to form a diploid nucleus. From the united gametangia without delay grows a long, usually tapering, multinucleate ascus within which are produced very numerous ascospores which are forced out of the apex of the ascus by the swelling of its contents or by the contraction of the stretched ascus wall, or both. From a primitive Ascomycete of this type it is suggested that by reduction in the number of nuclei per segment of mycelium the more typical monocaryon mycelium was derived. Indeed *Dipodascus uninucleatus* has that type of mycelium. Similarly the number of nuclei in the gametangium is assumed to have become reduced to one and the number of ascospores to have become standardized at eight or four. In this manner would have arisen the Endomycetaceae, the yeast-like derivatives of which are the Saccharomycetaceae. By a delay in the union of the gamete nuclei and their multiplication by conjugate division and then the branching of the zygote it is assumed that the

ascogenous hyphae arose, the nuclear union occurring in the terminal asci. The development of loose protective hyphae would give us the Gymnoascaceae and the transformation of these loose hyphae to a firm structure would produce the perithecial structures of the Aspergillaceae. From this it is then suggested that the Pyrenomycetes and eventually from them the Discomycetes have evolved. In all of these groups typically two gametangia unite, either equal in size, or modified into a smaller antherid and a larger oögone. Finally, at several points fertilization of an extension of the oögone by conidia instead of by antherids is assumed to have led to the production of spermagonia whose sperm cells fertilize the trichogynes in many Sphaeriales, Pezizales, Lecanorales and Laboulbeniales. This phylogenetic scheme is shown in figure 4.

Like many Mucorales the cell wall of the Ascomyceteae frequently contains chitin and only in rare instances, as in the ascogenous hyphae of some lichens, is cellulose so unmingled with chitin and other substances as to give the cellulose reaction when treated with chloriodide of zinc.

A further substantiation of the foregoing theory is the fact that the Mez (20) school claims a definite serum reaction between the "Protascales" and the Zygomycetes.

Guilliermond's (13) investigations on *Spermophthora* reveal an organism with an alternation of a coenocytic, branching gametophytic mycelium containing, presumably, haploid nuclei and a septate sporophytic mycelium of uninucleate cells with diploid nuclei. Terminal or subterminal gametangia are cut off by the formation of septa and within these are produced numerous fusiform gametes which are set free by the rupture of the gametangium. These unite, the nuclei uniting usually in the conjugation tube, and produce a few-celled, more or less branched mycelium of uninucleate cells, the terminal cells of which become spherical, eight-spored asci. He homologizes this limited monocaryon mycelium with diploid nuclei with the dicaryon ascogenous hyphae of more typical Ascomyceteae, the union of nuclei in the latter being deferred until the formation of the ascus. The union of distinct gametes is, in his opinion, a precursor of the condition in higher Ascomycetes where the two gametangia unite. This genus he considers as oc-

cupying an intermediate position between the Phycomycetes and Ascomycetes, with the Ascoideaceae, Endomycetaceae, etc. as lateral branches of the main line of ascent.

Anton de Bary, Atkinson, Gäumann, Mez and the great majority of modern mycologists held or hold to some form of the foregoing schemes, which derives the Ascomyceteae from the Phycomyceteae. Attention should, for the sake of fairness, be given to the hypothesis of Julius Sachs (23, 24) who suggested an entirely different mode of origin of the group. As one of the fundamental tenets of his theory of classification of the lower plants was the idea that fungi were polyphyletic and that those fungi that showed vegetative and reproductive structures similar to those of certain algae, are to be considered to have arisen from these algae by the loss of chlorophyll with the changes that such a loss would entail. Thus the Saprolegniales arose, according to him, from the Siphonales. The Ascomyceteae he suggests might have arisen from the vicinity of the red seaweeds. In the simpler members of this group, such as the Nemalionales, the plant body consists of branched filaments of uninucleate cells. Each transverse septum is centrally perforate, with a continuous cytoplasmic connection from cell to cell. Typically their sexual reproductive organs are an oogone with a long receptive extension, the trichogyne, and usually clustered antherids, often of the flask type, from whose interiors are pushed out the small, naked, sperm cells, with a large nucleus compared with the size of the cell. These non-motile sperms are transported by currents of water to the trichogynes to which they cling, secreting a thin cell wall and then dissolving an opening into the trichogyne into which the contents of the sperm pass. The sperm nucleus progresses toward the oogone, past the trichogyne nucleus which is present in a few forms, to the egg nucleus with which it unites. Usually with but little delay, this zygote nucleus undergoes division which is meiotic in the majority of the Nemalionales or mitotic in a few of this order and in the other orders of the red seaweeds. These resulting nuclei divide further and pass out into short or long filaments (gonimoblasts) whose terminal cells singly or successively back from the apical cell, enlarge and become the carpospores. Each of these, it is apparent, contains a diploid nucleus, where the nuclear division in the oogone was

mitotic or a haploid nucleus, where that division was meiotic. In the majority of the whole class the carpospores give rise to plants more or less similar to the gametophyte, but with diploid nuclei, and producing tetrasporangia, instead of sexual organs, within which occur meiosis and the formation of naked tetraspores, which in their turn give rise to the gametophytes. The sporophytes are much reduced in some genera and in *Liagora tetrasporifera* Borge-sen (5) showed that instead of carpospores, the terminal cells of the gonimoblasts are tetrasporangia.

The parallelism between red seaweeds and some of the Ascomyceteae is very striking: (1) Vegetative structures of filamentous, unicellular hyphae with perforate septa and continuity of cytoplasm from cell to cell, (2) formation in flask-shaped antherids of small, water-borne sperm cells, which are naked in the red seaweeds and in some of the Ascomyceteae, (3) presence of trichogynes on the oögones, to which the sperm cells cling and into which the sperm nuclei enter, (4) after the sperm nucleus reaches the oögone numerous branches arise from the latter into which pass the nuclei produced by the nuclear divisions in the oögone, (5) formation at the extremities of these branches of carpospores (in *Liagora* of tetrasporangia) in the red seaweeds, in the Ascomyceteae of asci in which meiosis occurs and ascospores are produced, (6) in some members of each group from the cells below the oögone arises a protective envelope surrounding the carpospores or asci, (7) several species of undoubted, higher red seaweeds lack chlorophyll and are parasitic upon other Florideae.

If the foregoing parallelism is accepted as indicating true relationship, and not an evolutionary convergence, it explains in a simple manner the occurrence in many Ascomyceteae of trichogynes and free sperm cells. The explanation of these by the advocates of the hypothesis of de Bary, Atkinson, Gäumann, etc. is that the primitive sexual reproduction in the class, was by the direct union of two gametangia and that by the progressive sterilization of the apical cells of the filament containing the female gametangium a trichogyne developed which could be fertilized by the male gametangium, and by further evolution, by conidia as substitutes for antherids, eventually these conidia becoming evolved into definite sperm cells. By the hypothesis of origin from the Florideae the

occurrence of the sperm cells and trichogynes is explained as a hold-over from the ancestral forms. *Collemodus* and *Ascobolus carbonarius* show the steps by which fertilization by free sperms changes to union of trichogyne with antherids. Progressive shortening of the trichogyne leads eventually to direct union of oögone and antherid.

If the Floridean ancestry of the Ascomyceteae is accepted the whole group must be stood on its head, as it were, as compared with the arrangement under the other hypothesis (FIG. 5). Those groups in which occur free sperm cells and oögones with trichogynes must be put first. Thus the Laboulbeniales with very Floridean types of sexual organs, many of the Pezizales and Lecanorales, and many of the Sphaeriales and Pyrenulales and some Hypocreales would occupy the more primitive position. It should be noted that it is among these fungi that the enveloping protective structures resemble most closely those of the red seaweeds. Instead of being the most primitive, the Aspergillales and Saccharomycetales would be the furthest evolved away from the primitive Ascomyceteae. The Taphrinales, especially if we include therein the Ascocorticiaceae, would be simplified forms of Pezizales with greater and greater disappearance of the excipulum and a more unlimited marginal growth of the hymenium.

As an argument against this hypothesis of the Floridean ancestry of the Ascomyceteae must be considered the failure of Mez to obtain by the serum diagnosis method any indication of the relationship of Ascomyceteae and Florideae. Furthermore the cell walls of the latter are composed of pectose-like substances or at best of cellulose-like substances. In the former cellulose and other carbohydrates are present in the cell walls but masked by the presence of chitin, with a very few exceptions.

It is accepted by most mycologists that the clamp connections of the Basidiomyceteae are homologous to the hooks or croziers of the ascogenous hyphae of the Ascomycetes. We must then postulate a common diverging origin of both classes from ancestors possessing these structures or the evolution of one class from the other. In origin and development the ascus and basidium are similar up to the final stage of spore-formation. We must therefore seek in the Ascomyceteae forms producing croziers on their as-

cogenous hyphae with other points of similarity that would suggest the possibility of evolution of one from the other. The Taphrinaceae have been suggested, but they lack the hook formation. The Ascocorticiaceae have been found by Rogers (22) to possess these. They are in general structure, except for the ascus, similar to *Corticium* or its relatives. Whatever source we choose for the origin of the Basidiomyceteae, we have to assume a mutation by which the internal ascospores became extruded into external pockets, thus forming the basidiospores. If the foregoing suggestion is accepted then the *Corticium*-like fungi represent the groups from which the rest of the class have developed. In some Basidiomyceteae the inner wall of the spore is free from the outer wall, suggesting that the latter is actually an extruded pocket containing a spore.

It must be pointed out that the well-developed spermatogonia of the Uredinales and the development of receptive hyphae or trichogynes may indicate an origin further down in the Ascomyceteae than *Ascocorticium* in which these appear to be lacking. If that is the case, is the promycelium (or basidium) of the Uredinales and Ustilaginales, as well as the basidium of the Auriculariales closely related to the basidium of the Eubasidiaceae? Are the Tremellales and Dacryomycetales related closely to the Auriculariales? How about their relationship to the Thelephoraceae? Can it be that the three orders of "jelly fungi" are externally similar by convergent evolution only? Does the formation of sperm cells on the monocaryon mycelium of these orders and of some of the Eubasidiaceae indicate a relationship through the Ascomyceteae to the Florideae or are these structures merely analogous but not homologous to the sperm cells of the groups mentioned?

Whence came the Gasteromycetes? Are they evolved from the Agaricaceae by further and further development of angiocarpy? Or must we seek their origin from the vicinity of *Corticium* by the adoption of angiocarpy to produce simple forms like *Protogaster*?

It will probably be long before mycologists are in agreement with regard to the problems outlined in this paper. It is hoped that the suggestions given here may stimulate thought along these lines.

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# THE MYCORRHIZA OF ZEUXINE STRATEUMATICA<sup>1</sup>

JOHN N. PORTER

(WITH 6 FIGURES)

*Zeuxine strateumatica* (L.) Schltr., an orchid native to south-eastern Asia, was first reported growing in Florida in January, 1936, west of Fellsmere. Ames (2) has given a thorough account of its occurrence in Florida between that date and June, 1938, reporting that the plant was spreading rapidly throughout peninsular Florida and that, unlike other orchids, it was showing a close affinity for cultivated land, occurring in such places as lawns and drainage ditches. The problem which then presented itself was that of determining the factors which influenced the dissemination and successful establishment of the orchid in an entirely foreign locality. Most orchids, including the genus *Zeuxine*, are known to be dependent to some degree on mycorrhizal fungi; therefore, it was desirable to learn the identity of the fungus with which *Z. strateumatica* is living in symbiosis and also the conditions under which the germination of seeds and maturation could take place. Consequently, this investigation was undertaken in order to study the mycorrhizal relationships of the orchid in question.

## DISTRIBUTION, GENERAL CHARACTERISTICS, AND MYCORRHIZAL RELATIONSHIP OF ZEUXINE

The members of the genus *Zeuxine* grow terrestrially in the rain forest at low altitudes in southeastern Asia and the neighboring islands. Previous to its discovery in Florida, *Zeuxine strateumatica* had been reported, according to Ames (1, pp. 276-277), from the Philippines, Afghanistan, India, Ceylon, Malay Peninsula, China, Assam, Japan, Java, and Amboina. Ames has propounded the interesting question of the origin of *Z. strateumatica*

<sup>1</sup> Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 194.

in Florida and its ability to spread so rapidly once it was established. He considers the possibility to be very strong that protocorms of the orchid were introduced from China with seeds of the centipede grass, *Eremochloa ophiuroides* (Munro) Hack. The absence of previous records is a strong indication that this is not an orchid species which has hitherto had representatives in both hemispheres. The fact that it readily grows in cultivated areas precludes the fact that it might simply have grown unobserved in Florida until recently.

*Zeuxine strateumatica* is a plant which ordinarily grows as an underground stem, the latter being the center of an axis at one end of which are produced the roots and at the other, during the proper season, the leafy shoot and eventually the inflorescence, composed of small white flowers. The lower leaves are short and adhere rather closely to the axis but the more terminal ones are much longer, erect, and of a linear character. The plant, when mature, is usually six or more centimeters long. In Florida it flowers in January and soon produces a considerable number of seeds. By the first of April it has completely vanished from above the surface of the ground and is again pursuing life as a subterranean stem.

There is a dearth of published work on the mycorrhizal aspects of *Zeuxine*, which may be partially accounted for by the fact that members of the genus, inconspicuous in appearance, are of little horticultural interest. Burgeff (4) has found that within the genus *Zeuxine* itself there is exhibited a definite trend from the autotrophic condition toward that of saprophytism and that this trend is correlated with dependence upon a mycorrhizal fungus. Using certain species (*Zeuxine clandestina* Bl., *Zeuxine* sp., and *Zeuxine purpurascens* Bl.) as examples he observed that *Z. purpurascens* had less leaf area and green pigmentation than did the two preceding species but with this closer approach to saprophytism was associated a more uniform and thorough fungus infection.

Burgeff noted and described fungus infection in all three of these species of *Zeuxine* but succeeded in isolating the endophyte, *Rhizoctonia mucoroides* Bern., in only one case, namely, from an undetermined species of *Zeuxine* from Tjibodas, Java. Burgeff has also isolated *R. mucoroides* from the following genera of

orchids: *Phalaenopsis* and *Vanda* of the Sarcanthinae group of Pfitzer; *Trichopilea*, *Odontoglossum*, and *Miltonia* of the Oncidiinae; and *Goodyera*, *Macodes*, *Vriidagzynea*, *Hetaeria*, and *Cystopus* of the Physurinae, to which group *Zeuxine* also belongs.

Bernard (3), who originally described the fungus, had isolated it from *Phalaenopsis amabilis* Lindl. and from *Vanda tricolor* Hook. He described the fungus as one which produces long aerial hyphae raised above the loose mycelial covering of the substrate. It forms on rich nutrient media a brownish-gray felt, the young cultures according to him being reminiscent of *Sporodinia* or *Mucor*. Branched monilioid chains of conidia anastomose to form small, irregular sclerotia abundantly on the surface of the substrate. These sclerotia are whitish at first but soon assume a deep brown color. Burgeff's (5) observations, however, did not completely coincide with those of Bernard. Burgeff found that very large and strong sclerotia were frequently formed and that there were different strains of the fungus. The strains from the terrestrial orchids related to *Zeuxine* were found to exhibit distinct physiological differences from the *Vanda* and *Phalaenopsis* fungi. The fungus in question is associated with orchids which taxonomically are very close together in the individual groups, although the groups themselves are well separated in the family Orchidaceae. These relationships indicate that there is a close and specific relation between orchid and fungus, and, based on the six genera of the Physurinae from which *R. mucoroides* has already been isolated, the suggestion may be made that this fungus will be isolated from other members of the group. The question now arises as to whether the isolates obtained by Burgeff are strains or are actually different species of *Rhizoctonia*. Unfortunately, as yet not enough is known about these fungi to determine this point with accuracy.

THE ISOLATION OF RHIZOCTONIA MUCOROIDES FROM ZEUXINE  
STRATEUMATICA AND DESCRIPTION OF THE FUNGUS  
IN CULTURE

Fungus isolations were attempted in February, 1937, from plants shipped by air mail from Florida. The roots were kept fresh by retaining around them a moist clump of the earth in which they

had been growing. Rhizomes as well as roots were thoroughly scrubbed with brush, soap and water and were sectioned after first being sterilized on the exterior with 7 per cent calcium hypochlorite. Since there is only a simple epidermis and not a velamen present in the case of *Zeuxine* the roots were merely cut into sections about 5 mm. long and inserted in the agar. The isolation medium was the "Mn + N" medium of Burgeff (5), consisting of the necessary mineral salts and three grams per liter of starch as a source of carbohydrate.

The first attempted isolation ended in failure, most of the petri plates remaining sterile and the others showing only a species of *Fusarium*. Since the portions to be placed in agar had been left in the sterilizing solution for an excessive amount of time (over one-half hour) it is to be supposed that the endophyte was prevented from growing, as were most of the contaminants. The absence of a velamen may also have been a factor contributing to the rapid penetration of the calcium hypochlorite into the cells which contained the mycorrhizal fungus. A second attempt was made in January of the following year from plants obtained from Florida in the same manner as described above. Care was taken this time that the roots and rhizomes be left in the calcium hypochlorite solution for only fifteen or twenty minutes. Considerable contamination occurred in these second cultures, but a radially growing fungus occurred quite uniformly and soon began to produce monilioid chains of conidia in abundance (FIG. 1).

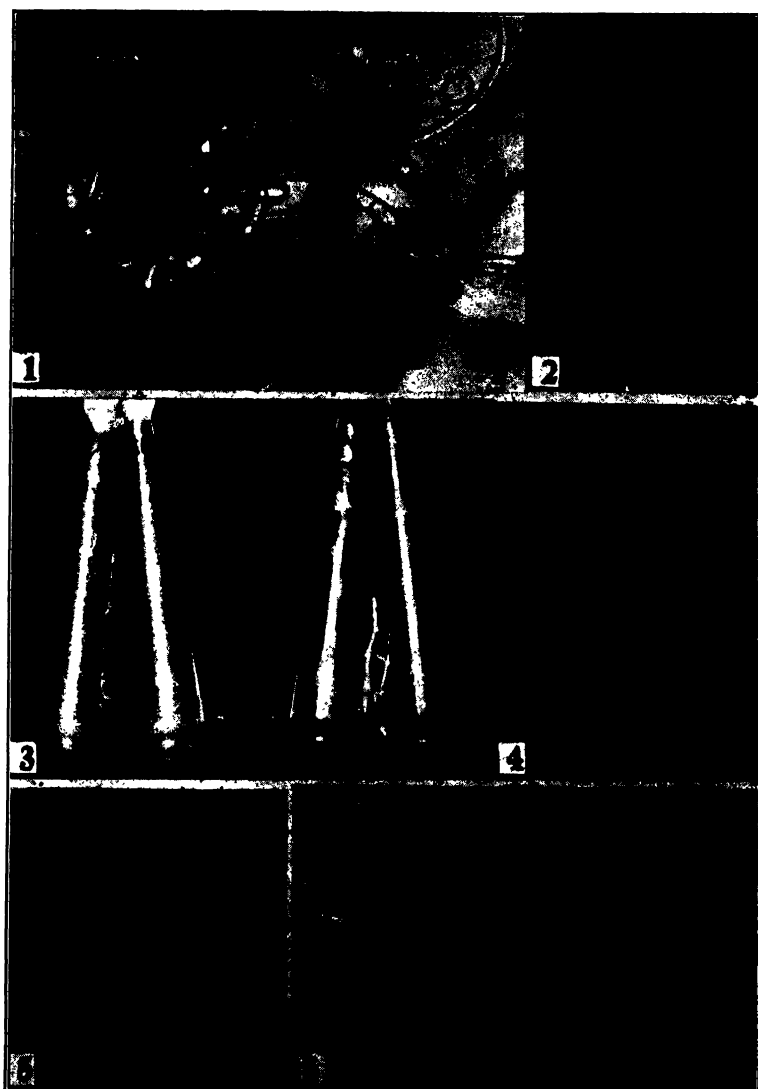
When grown in pure culture this fungus produced a light, cottony mycelium the color of which soon turned to dark brown. The hyphae showed some tendency to grow upon the glass sides of tubes or petri plates. Conidial chains of the type characteristic of the genus *Rhizoctonia* were abundantly produced in the agar, no other types of reproduction being observed, although brown sclerotia were formed from masses of monilioid conidial chains (FIG. 2). Measurements made at the end of a growth period of two weeks on Burgeff's "Of" stock medium (containing more starch than the "Mn + N" medium and no source of nitrogen) showed that individual cells of the chains of conidia averaged  $21\ \mu$  long and  $15\ \mu$  wide, while the hyphae averaged  $6.4\ \mu$  in width. The figures just given compare very closely with Burgeff's figures

for *Rhizoctonia mucoroides* isolated from *Zeuxine* and other genera of the Physurinae. This fact, coupled with the close similarity of the general descriptions of the two fungi, leaves no doubt that *R. mucoroides* is the endophyte associated with *Zeuxine strateumatica*.

#### THE RESULTS OF ATTEMPTED SEED GERMINATION ON CULTURES OF THE ENDOPHYTIC FUNGUS

It is generally considered that the final test as to whether a given fungus is active in orchid mycorrhiza or is merely a soil saprophyte is its ability to promote germination of the seeds of the orchid genus from which it was isolated. Therefore, in order to determine whether the fungus isolated as described above would aid in germination of *Zeuxine strateumatica*, a quantity of seeds was obtained from Professor Oakes Ames in Ormond, Florida, soon after the fungus isolations were made. After being sterilized for 20–30 minutes in a filtered 7.5 per cent solution of calcium hypochlorite the seeds were sown February 14, 1938, on cultures of *R. mucoroides* growing on agar in 500 c.c. Erlenmeyer flasks. The medium used was the "Sb" medium of Bärgeff in which starch is again the source of carbohydrate. Ammonium sulphate was used in place of the recommended sodium nucleinate, however, because it was more readily available. Six flasks were thus prepared, three of which were placed in diffuse light in the greenhouse and three in complete darkness, but at the same temperature (72° F. in winter). A small amount of additional seed material was obtained from the same source a short time later and these seeds were sown in three more flasks, each of which contained Knudson's (8) medium (with sucrose as a carbohydrate source) but no fungus. These flasks were placed in diffuse greenhouse light.

No evidence whatsoever of germination was observed by June 1, 1938, and further observations were not made until October 9 of the same year. Then it was noted that of the three flasks placed in the darkness two showed no germination, while in the third were two etiolated plants in close proximity, one 33 mm. tall and the other 46 mm. (FIG. 3). Of the three flasks originally placed in



FIGS. 1-6. 1, Mycelium and monilioid spore chains of *Rhizoctonia mucoroides* ( $\times 240$ ). 2, Appearance of *R. mucoroides* in stock culture. Sclerotia are being formed on the wall of the test tube ( $\times \frac{3}{4}$ ). 3, *Zeuxine strateumatica* plants one year after sowing. Flask on left has been kept in the light, that on right in the dark ( $\times \frac{1}{8}$ ). 4, New shoot in originally illuminated flask at end of second year ( $\times 1$ ). 5, The same viewed from the bottom of the flask ( $\times 1$ ). 6, New shoot in flask originally placed in the dark; end of second year ( $\times 1$ ).

diffuse light all showed germination to some extent. In the second flask were counted nineteen seedlings, all 5–15 mm. long, but likewise not appearing above the surface of the agar and most of them occurring at its extreme edge. In the third flask there was only one plant (FIG. 3) but strangely enough it had attained a height of 74 mm., approaching the normal height of plants of this species in nature. The fact that almost all of the seedlings grew at the edge of the agar would indicate their need for the increased aeration or moisture occurring there. No germination whatsoever occurred with the seeds sown asymbiotically on Knudson's medium.

After the time of the examination just discussed, all flasks were kept in diffuse light in the greenhouse. The subsequent behavior of the seedlings was somewhat disappointing. It was hoped that at least one of the three large plants would produce an inflorescence by the first of March. However, they all collapsed upon the surface of the agar by mid-March and from then until the following autumn continued their existence as rhizomes below the surface of the substrate. Early in the fall of 1939 these plants had again produced shoots (FIGS. 4, 5, and 6) but this time they were much shorter (10–20 mm.) than those of the preceding year. No increase in height was noted after the middle of October, and their behavior in March was similar to that of the previous year. The many seedlings which were produced and then stopped growth beneath the surface of the agar remained quiescent, but alive, since their initial growth in the summer of 1938. On the other hand, the underground stems of the large plants gradually increased in diameter and length and obtained a certain amount of chlorophyll.

#### THE HISTOLOGICAL RELATIONSHIP BETWEEN ENDOPHYTE AND ORCHID

In order to study the position of the fungus within the tissues of the more or less dormant rhizomes, some of them were removed from the agar, cut into sections about five mm. in length, fixed in F.A.A. (formalin-acetic-alcohol), and stained by Durand's (7) method. The rhizomes, 15–20 cells in diameter, were found to be rather abundantly infected with the hyphae of *Rhizoctonia mucoroides*. Any cells, other than the epidermal cells or those of

the very slender central strand, were liable to contain fungus hyphae; infection, however, was limited to the cells of the side of the rhizome which was turned toward the agar. This, of course, applied to those plants which were growing at the extreme edge of the agar and between it and the glass. Cells were not observed in which digestion of the hyphae seemed to be taking place, all hyphae appearing to be in good condition. The nuclei of infected cells had lost their globular shape and were enlarged and distorted. The latter probably occurred as the result of the pressure of the massed hyphae on the nucleus. Those cells of the cortex which contained no fungus hyphae were partially filled with globular masses of starch. Such starch masses were completely lacking in infected cells.

#### DISCUSSION

That *Rhizoctonia mucoroides* is the endotrophic fungal symbiont associated with *Zeuxine strateumatica* in Florida is clearly indicated by the results of this investigation. Since the fungus seems necessary for the germination of seeds of this orchid and for its normal development and since the plant has begun to spread extremely rapidly in Florida one is led to suppose that *R. mucoroides* had already been established as a saprophyte in that area or as the symbiont of other species of orchids. The writer has been unable to discover any previous record of the isolation of *R. mucoroides* in America. Curtis (6), who has isolated from American orchids most of the mycorrhizal species of *Rhizoctonia* hitherto described, has not reported finding *R. mucoroides*. The most probable assumption of the origin of the fungus in Florida is that it had already infected protocorms of *Z. strateumatica* when they became mixed with seeds of centipede grass, and that these protocorms were a source of inoculum for the soil immediately surrounding the places where they were sown upon their arrival in Florida. The interval between the introduction of centipede grass into Florida (1917) and the period when *Z. strateumatica* became prevalent there may well be accounted for by the amount of time necessary for *R. mucoroides* to become established in the soil. A second possibility is that spore chains or sclerotia of the fungus



adhered to the grass and orchid seeds and were thus introduced at the same time. The sclerotia in particular would be able to withstand long periods of desiccation or other unfavorable conditions.

The fact that *R. mucoroides* has now been isolated from species of the genus *Zeuxine* in both Java and Florida is another important bit of evidence that there is an extremely close and specific relationship between orchids and their endotrophic symbiotic partners. That is to say, a single fungus species or a limited number of species are constantly associated with any given orchid species in nature. This fact in itself may account for the extreme geographical limitation of many species of orchids.

The synthesis of seeds with fungus has presented results which are interesting but not readily explainable. As previously stated, a need for the increased aeration and moisture occurring at the edge of the agar is probably the reason that most of the seedlings produced in the germination tests grew there. No valid explanation can be offered immediately concerning the three plants which obtained nearly normal size while the rest failed to push up from the agar. That the most rapid growth took place during the hot summer months indicates, however, that these plants are affected by temperature to a considerable extent. Temperature may also be an important factor in the failure of the one plant that reached normal size to produce an inflorescence.

Another possible answer to the perplexing question raised by the apparently aberrant behaviour of most of the seedlings has been supplied by the histological examination of the tissues. The absence of cells in which the digestion of fungus hyphae is taking place may explain the fact that the majority of plants produced have for a long time maintained a static rhizomatous condition in the agar. Normally, one finds cells in which digestion is taking place interspersed with those in which the hyphae are maintained in their normal manner (*Verdauungszellen* and *Pilzwirtzellen*), or these cells may be arranged in definite layers. It is considered probable by most workers in the field that the higher plant derives proteinaceous material and fatty substances from the fungus. If the usual digestion fails to occur one would then expect the higher plant to be arrested in development or parasitized. The lack of

proper aeration or moisture in the agar medium undoubtedly play their part in the inhibited development of these plants and may be the reason why the plants are unable to control completely their symbiotic partner.

The present investigation has been limited in scope since only a small amount of *Zeuxine* seed material has been available. However, because it develops very rapidly into a mature plant, *Zeuxine strateumatica* should be a satisfactory subject for future experimentation on orchid mycorrhiza. In particular, it would be very desirable to discover whether other species of *Rhizoctonia* isolated from various orchids not related to *Zeuxine* will promote germination in the latter.

The writer takes pleasure in expressing his appreciation to Professor William H. Weston, under whose supervision this study was made, and to Professor Oakes Ames for so kindly furnishing the seed and root material.

#### SUMMARY

1. *Rhizoctonia mucoroides* has been shown to be the mycorrhizal associate of *Zeuxine strateumatica* in Florida.

2. Seeds of *Zeuxine strateumatica* sown on cultures of *Rhizoctonia mucoroides* growing on the "Sb" medium in 500 c.c. flasks germinated in 6-8 months from the time of sowing.

3. Better germination was obtained in flasks kept in diffuse light in the greenhouse than in those placed in the dark.

4. No germination was obtained asymbiotically.

5. All indications are that the relation of fungus to orchid is, in this case, a specific one.

6. Because of its rapid development, *Zeuxine strateumatica* is worthy of future experimentation in the field of orchid mycorrhiza.

LABORATORIES OF CRYPTO GAMIC BOTANY,  
HARVARD UNIVERSITY,  
CAMBRIDGE, MASS.

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# SOME SPECIES OF PAPULASPORA ASSOCIATED WITH ROTS OF GLADIOLUS BULBS <sup>1</sup>

H. H. HOTSON <sup>2</sup>

(WITH 2 FIGURES)

The genus *Papulaspora* was erected by Preuss (2), in 1851, for an imperfect fungus which produced bulbils. Intervening work was thoroughly covered in 1912 by J. W. Hotson (2) in the introduction to his comprehensive monograph of the genus. This monograph and its 1917 revision (3) are the classic work on the genus with complete keys and detailed descriptions of the 25 species then known, and should be consulted for the taxonomy, morphology, and development. As is well shown in this monograph, these fungi are typically saprophytic in habitat and are found on dung, in the soil, and on various kinds of decayed fruits, etc. However, since B. O. Dodge and T. Laskaris (1) recently have found a *Papulaspora* associated with the rotting of *Gladiolus* bulbs, it seemed to the writer of interest to determine whether this species is indeed an active parasite on *Gladiolus* or merely a saprophyte, and, if a saprophyte, whether, perhaps, other species may not be involved. Toward this objective the following paper is merely a preliminary report, since the present emergency cut short the comprehensive study originally planned.

bulbs originally from Long Island, New York, kindly supplied, together with certain cultures, by B. O. Dodge to whom the writer is deeply indebted. From this material three species of *Papulaspora* were isolated, *P. Gladioli* (= *P. Dodgei*), *P. coprophila*, and

<sup>1</sup> Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 197.

<sup>2</sup> This work was begun at the University of Washington under the guidance of J. W. Hotson; continued at Cornell University where facilities were offered by H. M. Fitzpatrick; and completed at Harvard University under the guidance and inspiration of Wm. H. Weston, Jr. To these men the writer is deeply indebted.

a third, which, as it proved to be new, is described as *P. appendicularis*. It is of interest to note that all of these were found under similar conditions as saprophytes on decayed bulb material resulting from previous infection by *Sclerotinia* (*Botrytis*) sp. The fourth species, *P. rubida*, previously found on *Gladiolus* in Pennsylvania by C. C. Wernham (5) and at first confused with *Urocystis Gladioli* (4) was very generously furnished by Dr. Wernham.

In making isolations, acid media, pH 4.8, were used, thus inhibiting bacterial growth sufficiently so that uncontaminated transfers to pure culture could be made. The fungi were cultured on potato-dextrose agar and on a synthetic medium whose formula, because it proved especially successful, is given here in the hope that it may be useful to others:

|               |         |                 |           |
|---------------|---------|-----------------|-----------|
| Starch (C.P.) | 30 gms. | Peptone (Bacto) | 5 gms.    |
| Malt (Bacto)  | 10 gms. | Dextrose (C.P.) | 10 gms.   |
| Agar (Bacto)  | 15 gms. | Water (dist.)   | 1000 c.c. |

Of the 25 species of *Papulaspora* which have been described, only one has been previously reported as such from *Gladiolus* bulbs, and this one and the other three have certain points in common. From the other species of *Papulaspora* these forms on *Gladiolus* may be separated by the following characters:

The primordium involves more than one cell; the mycelium lacks clamp-connections; the bulbils are yellowish-red to dark brown at maturity.

To facilitate the identification and differentiation of the species considered here, the following key will prove helpful:

- A. Bulbils dark brown at maturity when seen in gross culture.
  - B. Primordium a single lateral branch.
    - C. Bulbils formed by the coiling of a single lateral branch in three dimensions, primordium not a spiral; conidia absent.
      - 1. *P. Dodgei*.
    - CC. Primordium a spirile, conidia borne on bottle-shaped sterigmata ..... 2. *P. coprophila*.
  - BB. Primordium many lateral branches which fuse to form the bulbil; conidia borne on bottle-shaped sterigmata.... 3. *P. appendicularis*.
- AA. Bulbils a brick red at maturity when seen in gross culture.
  - 4. *P. rubida*.

In the following survey of these species, points of similarity and of difference will be considered in more detail.

**Papulaspora Dodgei** Connors, sp. nov.<sup>1</sup>

*Papulaspora Gladioli* H. H. Hotson.

A description of this species was provided by B. O. Dodge and T. Laskaris (1) and need not be repeated here. In a previous article, the writer (4) has shown that *Urocystis Gladioli* (Req.) Smith is distinct and separate from *Papulaspora Gladioli* (= *P. Dodgei*). This species is very striking in color, staining the medium dark brown and at maturity forming bulbils which are also dark brown. The staining of the culture medium is an easily recognizable character and one of the most striking. The bulbils average  $44\ \mu$  in diameter with a range of from  $24\text{--}64\ \mu$ . The growth of this organism is very rapid, mature bulbils being formed in 3–7 days. The majority of the writer's isolations from diseased bulbs were of this species and according to Dodge they were found in 20 per cent of the storage bulbs examined by him.

**PAPULASPORA RUBIDA** Hotson (J. W.)

This material came to Cornell from C. C. Wernham (5) as *Urocystis Gladioli* (Req.) Smith but upon further examination proved to be *Papulaspora rubida* which had been described by J. W. Hotson (2), in 1912. In the culture from Wernham, the fungus did not produce the spiral primordia which are characteristic of this species. However, comparison with the type material at the Farlow Herbarium leaves no doubt that these two fungi are identical.

**Papulaspora appendicularis** sp. nov.

Mycelium white, procumbent, profuse and matted; bulbils formed by the fusion of many lateral branches which usually arise around a central, septate hypha; more or less irregularly shaped, colorless when young, becoming light brown and finally dark brown at maturity; average diameter  $60\ \mu$  with the extremes from  $32\text{--}100\ \mu$ , often elongated and distinctly irregular (FIG. 1, *a + b*). Primordium not a spiral but consisting of many lateral branches. Conidia borne on bottle-shaped sterigmata especially in very young cultures (FIG. 1, *c*).

<sup>1</sup> See note at the end of this paper.

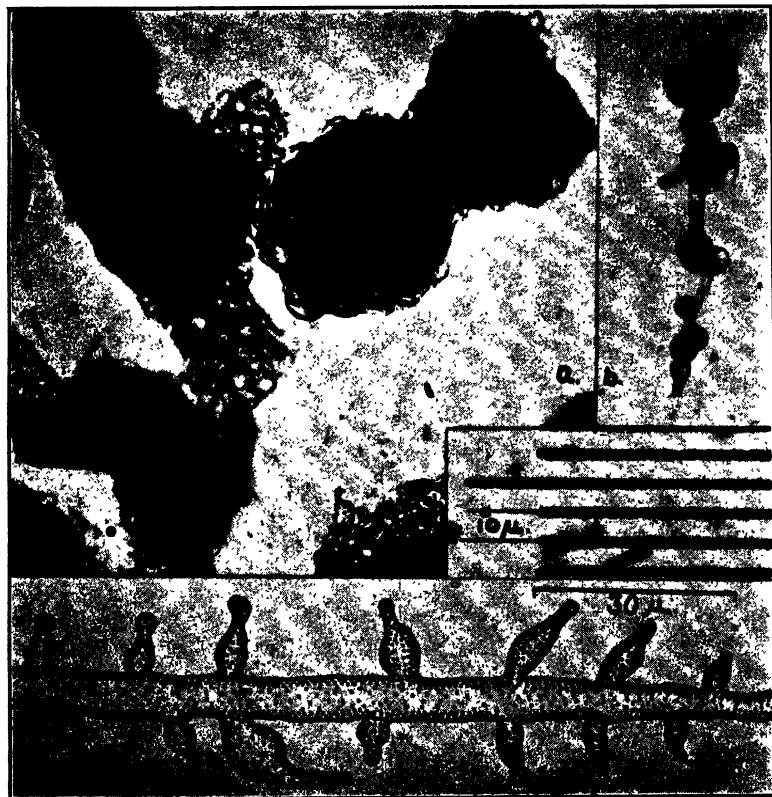


FIG. 1. *a + b*. Bulbils of *Papulaspora appendicularis* from prepared slides,  $\times 400 \pm$ , cf. scale. *a*, mature bulbils; *b*, early stages in bulbil formation; *c*, conidial stage, showing lateral bottle shaped sterigmata developing conidia, camera lucida drawing from living material,  $\times 550 \pm$ , cf. scale.

Mycelium album, procumbens; bulbilli e ramorum multorum lateralium, e hypha centrali septata ortorum, anastomosi efformata, forma elongati, irregulares, colore maturi atro-brunnei,  $32-60-100 \mu$  diam.; conidia in sterigmatibus lageniformibus producta.

This species, which appeared in very few isolations, is clearly distinguished from the others isolated from *Gladiolus* bulbs both by its many lateral branches and by the much larger size of its bulbils (FIG. 2). On comparison with other species of *Papulaspora* this species shows some general resemblance to *P. polyspora* Hotson (J. W.) but the latter has even larger bulbils ( $119-122 \mu$  in diameter) composed of distinctly angular cells. After successful

comparisons the characteristics of the present species seem sufficiently distinctive to justify describing it here as a new species, *P. appendicularis*.

#### TYPE MATERIAL.

Farlow Herbarium, Harvard University.

Herb. of Plant Path. Dept., Cornell University.

#### PAPULASPORA COPROPHILA (Zukal) Hotson (J. W.)

Although this species, originally described by J. W. Hotson, in 1912, has been isolated from soil and has been reported as growing on dung, in this case it was found growing saprophytically on bulbs of *Gladiolus* previously attacked by *Sclerotinia* (*Botrytis*) sp.

The coiled primordia are most conspicuous in the younger stages of the growth of this species. In 50 hour cultures this character is easily seen as well as the conidia which are borne on bottle-shaped sterigmata. However, when this species is grown for a period of time on artificial media it loses its ability to produce these spirile primordia. Whether this fungus can be made to produce these structures again is an interesting problem which should be worked out. Possibly nutrition is involved and the artificial media lack certain ingredients essential for normal growth and spirile production by the fungus. The purpose of these conspicuous coils is not known. Whether they are vestigial sex organs which have degenerated or whether they are undeveloped sex organs is a question which has not, as yet, been answered.

The foregoing survey brings up certain points of interest. Within the limited area of Long Island, N. Y., there are besides *Papulaspora Dodgei* two other species which occur as saprophytes upon the diseased bulbs of *Gladiolus*. Of these, *Papulaspora coprophila* was described by J. W. Hotson, in 1912, but has never been previously reported from this source, while *Papulaspora appendicularis* is a new species as yet reported from this source alone. In addition, *Papulaspora rubida* has been found on *Gladiolus* in Pennsylvania. By examining material from other sources it may be possible to discover additional *Papulasporas* associated with the rots of *Gladiolus* bulbs. It also is possible that there may be some



species of *Papulaspora* associated with rots of *Gladiolus* bulbs in Europe, which because of the confusion with *Urocystis Gladioli* (W. G.) Smith have been overlooked. In any case, this survey, although limited, seems to indicate that there is here an ample field for future work.

In conjunction with the foregoing it seemed of interest to the writer to ascertain whether *Papulaspora Dodgei*, the only one of the species on this host which has been suspected of parasitism,

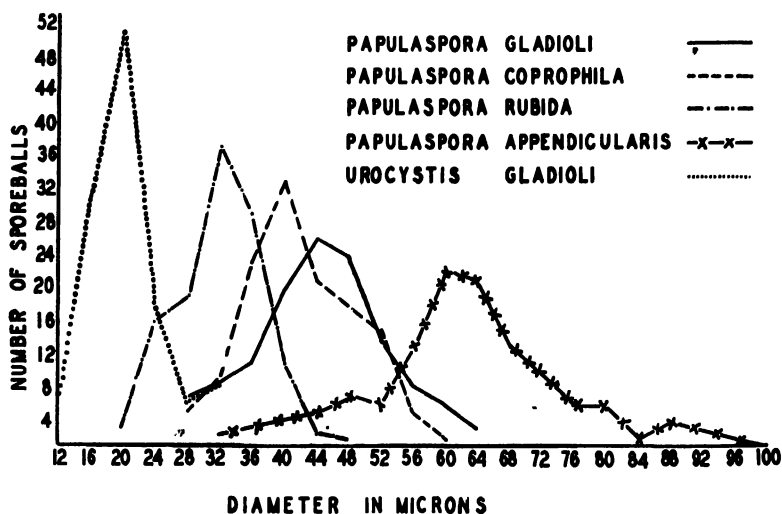


FIG. 2. Graph showing comparative sizes of bulbils of four species of *Papulaspora* from *Gladiolus* and also the spore-ball sizes of *Urocystis Gladioli*. Based on 200 random measurements of each.

really causes a disease. Since former workers were unable to reinfect the *Gladiolus* with this organism and because some doubt has been cast on the pathogenicity of this fungus, the writer carried out the following experiments:

In the greenhouse, 48 plants were used; 24 at 70° F. and 24 at 80° F. Eight of each of the three varieties, Alice Tiplady, Souvenir, and Halley were used, four being controls and four being inoculated in each series. The young shoots were inoculated from culture when they were about one inch in height and kept under normal growing conditions. Two of the four were inoculated by wounding and two by inserting the bulbils of the *Papula-*

*spora* inside the leaf sheath. The tests were run for a period of three months and were apparently completely negative since all the inoculated plants as well as the controls remained healthy.

In addition to this, it seemed interesting to carry out similar inoculations on these bulbs grown in nutrient solutions, *in vitro*, rather than in soil. Accordingly, three of each of the varieties were grown in nutrient solutions (Hoagland's) in the laboratory and were inoculated with the fungus. Although they had to be potted and transferred to the greenhouse at the end of three weeks because of mold contaminations, yet after three months the results were apparently negative as both the inoculated plants and the controls remained healthy.

Hence, from the point of view of the grower, this *Papulaspora* at least is not important as a cause of bulb loss, for which some other organism, often *Sclerotinia* (*Botrytis*) sp., may be responsible. This seems to be corroborated by evidence from the writer's many isolations from *Gladiolus* for the several *Papulasporas* seemed to accompany the one regularly occurring *Botrytis* as a saprophytic secondary invader.

#### SUMMARY

Associated with the rots of the bulbs of *Gladiolus* the writer has isolated the following species: *Papulaspora Dodgei* Connors, *P. rubida* Hotson (J. W.), *P. appendicularis* Hotson (H. H.), and *P. coprophila* (Zukal) Hotson (J. W.). Of these *P. appendicularis* is here described as new. These fungi are saprophytes living on the decayed bulb tissue caused by the primary infection of some other organism, in this case, *Sclerotinia* (*Botrytis*) sp., and by themselves do not cause a disease of the *Gladiolus*.

BIOLOGICAL LABORATORIES,  
HARVARD UNIVERSITY,  
CAMBRIDGE, MASSACHUSETTS

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## NOTE

Dr. I. L. Connors of the Central Experimental Farm, Ottawa, Canada, in a letter to the writer, has called attention to the fact that Hotson (Mycologia 34: 52-58. 1942) had created a homonym in describing *Papulaspora Gladioli* Hotson, a name preëmpted by *Papulaspora Gladioli* (Req.) Dodge & Laskaris, and sent the writer a copy of the manuscript he intended to publish to correct the mistake. In view of the fact that Mr. Hotson is in the armed services, and also in view of the fact that Connors' manuscript did not completely cover the situation, and also to save delay in printing the present paper without having to perpetuate an error, the writer feels that it is desirable to clarify the nomenclatorial situation. There is little doubt that the material communicated by Miss E. M. Wakefield and cited in Hotson's earlier paper is *Urocystis Gladioli* W. G. Smith and accordingly that name is valid, but there is some doubt concerning the status of *Uredo Gladioli* Reiquien since the original description could apply to either *Urocystis* or *Papulaspora*. In the Curtis Herbarium, however, there is a specimen from Duby, labelled in Curtis' handwriting:

Uredo Gladioli Duby!  
fol. Gladioli  
Duby

It would seem that this is an authentic specimen, if not a part of the type, as would be implied by the exclamation point. An examination of this specimen shows it to be the telial stage of the rust, *Puccinia Gladioli* Cast., of which, according to the International Rules, Article 57, *Uredo Gladioli* Req. becomes a synonym, and, according to Article 54, paragraph 2, so does *Papulaspora Gladioli* (Req.) Dodge & Laskaris. Since *Papulaspora Gladioli*

Hotson is invalid because a later homonym, it becomes necessary to assign to the imperfect fungus a new name and consequently, since this was the name proposed by Conners in his intended paper, it is only fitting and proper that the species should be labelled **Papulaspora Dodgei** Conners sp. nov., and that *Papulaspora Gladioli* Hotson be considered a synonym thereof. The Latin diagnosis required to validate the species, follows:

Mycelium primum albidum, profusum; hyphis septatis, cellulis multinucleatis; bulbulis ex stipitibus septatis oriundis, pallide brunneis vel atro-brunneis, sphaericis, 29–64  $\mu$  diametro, cellulis centralibus 1–6 raro pluribus, atro-brunneis, multinucleatis, cum corio unico cellularum pallide fulvarum circumdatis; hyphis primordialibus prope apicem spiraliter convolutis. Conidia absunt.

DAVID H. LINDER  
FARLOW HERBARIUM  
CAMBRIDGE, MASS.

# TWO CASES OF UNUSUAL DEVELOPMENT OF FRUIT BODIES<sup>1</sup>

CLYDE M. CHRISTENSEN

(WITH 3 FIGURES)

Those who are familiar with fleshy Agaricales know that the geotropic response which results in an orientation of pores, gills, or other spore bearing surfaces perpendicular to the surface of the earth, sometimes goes awry, especially if fruit bodies are diseased or mechanically injured. Fruit bodies produced in unnatural environments, as on agar cultures or on wood in jars, sometimes exhibit a capricious orientation of pores or gills, indicating that forces other than gravity are involved in such orientation. Following will be described two interesting cases of such nongeotropic development.

The first case involves an agaric (*Russula* sp., tentatively identified as *R. atropurpurea* Peck) observed at Itasca Park, Minnesota, in September, 1937. More than a decade before that time several pits about 5 feet square and 4 to 5 feet deep had been dug for experimental purposes in the level ground in a Jack pine stand. During a rainy spell in September, 1937, when fleshy fungi were rather abundant, the writer observed 2 fruit bodies of this species of *Russula* growing out of the vertical walls of one of the pits. One appeared about a foot from the surface of the ground, the second about 2 feet from the surface and on an adjoining wall. The stem of each, although short, extended straight out from the vertical wall, no upward curve being visible. The cap in each case was parallel to the wall. The gills were normal, although the free edges of those on the upper side bent over as they lost their turgidity with age, as can be seen in figure 1. In other words, the fruit bodies were oriented in the same way to the perpendicular surface from which they grew, as fruit bodies growing on approximately

<sup>1</sup> Paper No. 457, Misc. Journal Series, Minnesota Agricultural Experiment Station.

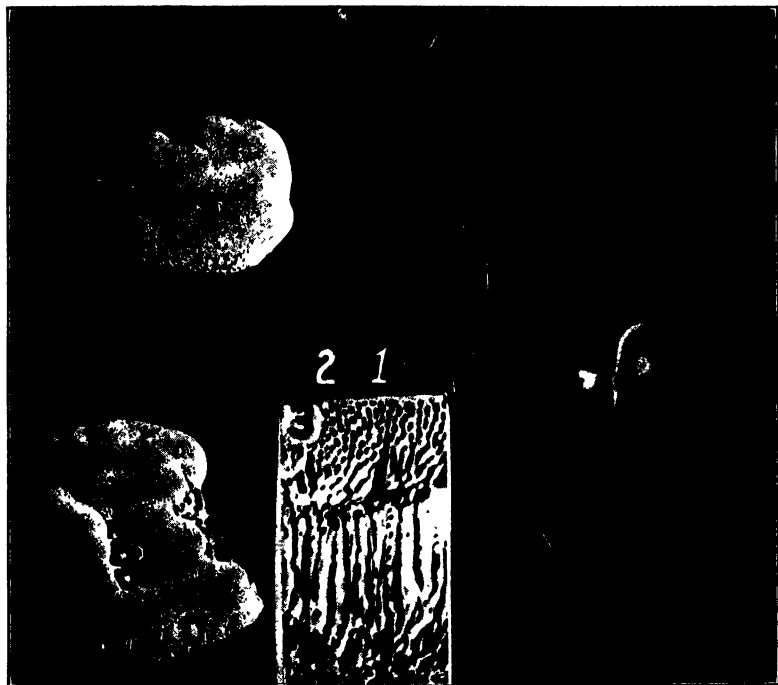


FIG. 1. *Russula* sp. growing out of the vertical wall of a pit. The surface of the ground is indicated by the carpet of needles; needles also cover the floor of the pit in the lower right corner of the picture. FIG. 2. Two sphaeroid fruit bodies of *Daedalea confragosa* which developed from normal fruit bodies. FIG. 3. A portion of the elongate pores on the central part of the lower edge of the lower fruit body in figure 2 enlarged to show the smaller horizontal pores in the walls of the larger ones.

flat ground are oriented to that. Both fruit bodies were attached to mycelium in the side of the wall, and were observed in their development over a period of two or three days. Certainly gravity had very little influence on the growth of the fruit bodies.

Second case. In October, 1940, a trunk of a dead willow two to three inches in diameter, collected in a swamp near Minneapolis, and bearing nine fruit bodies of *Daedalea confragosa* (Bolt.) Fries in various stages of maturity, was brought into the laboratory. The pores of all these fruit bodies were mainly daedaloid, only a few being lamellate. Since the fruit bodies were quite fresh, and it was thought that they might continue to enlarge, the trunk was placed in an upright position in a quiet corner of the laboratory,

with the lower end in a jar containing about 6 inches of water. It remained in this position throughout the period of observation, approximately six weeks, the water being renewed as necessary. The pores of the two lower fruit bodies continued to elongate, and in several weeks had grown about a quarter of an inch in length. They retained their normal shape and size, but very numerous smaller pores developed horizontally through their walls (FIG. 3). At the same time, pores arose over most of the upper surface of these two fruit bodies, transforming them into globoid structures illustrated in figure 2. These pores on the upper side pointed outward from the center of the fruit bodies. As can be seen in the illustration, they are smaller and more regular in shape than the pores on the lower side of the fruit bodies.

The hymenium of these anomalous pores, both the small pores extending horizontally through the pores on the lower side of the fruit bodies and those on the upper side, appeared normal, bearing immature and mature basidia, upon which occasionally four sterigmata could be seen. Cystidia with branched tips also were present. Few basidiospores were found in any of the pores, but this may have been due to the relatively dry air of the laboratory.

None of the upper seven bodies continued to grow after the tree trunk was brought into the laboratory, doubtless because of lack of water. Since the position of the trunk in the laboratory during the period of abnormal growth was approximately the same as its previous position in the field, and since the force of gravity obviously was about the same in the two locations, forces other than gravity must have been involved in the orientation of the pores. Apparently the normal tropic response to gravity is conditioned by a rather delicate balance that can be upset easily.

These two cases present exceptions to the general rule of geotropic response in this group of fungi. While one obviously cannot doubt that the formation of fruit bodies of Agaricales normally appears to be influenced by gravity, it may be fairly questioned whether geotropic growth responses regulate the formation of such fruit bodies so much as we have supposed.

# NEW PROPOSALS RELATING TO THE GENERA OF THE BOLETACEAE

WALTER H. SNELL

(WITH 1 FIGURE)

A short time ago (Snell, 1941), a modification of Gilbert's arrangement of the genera of the Boletaceae (1931) was presented as an improvement upon the one most commonly used on this continent—the tri-generic scheme of Peck (1889), which used as tribes of the genus *Boletus* the subgroups of Fries (1863 & 1874) with minor modifications and additions. Recently, Rogers (1941) demonstrated that S. F. Gray's *Natural Arrangement of British Plants* (1821) is post-Friesian, at least as far as the first volume of the *Systema* is concerned. Accordingly, Gray's generic names must be given the consideration that has been denied them by recent mycologists in the uncertainty that has prevailed concerning the priority status of the *Natural Arrangement*.

In Gray's family Hymenothecae, two of the subfamilies (or tribes?) are the Boletideae and the Suillideae. The Boletideae contain species that are present-day Polyporaceae. The laterally attached species, whether corky, coriaceous or woody, are placed in the genus *Boletus*, but obviously this use of the name is of no interest to us because in the first volume of the *Systema* a few months before, Fries had established that genus in the present-day Boletaceae. The Suillideae include the forms that are fleshy and have long tubes separable from the cap and either united or distinct from each other, in the four following genera: *Suillus* Micheli, *Pinuzza* Micheli,<sup>1</sup> *Leccinum* Micheli,<sup>1</sup> and *Fistulina* Persoon.

*Fistulina* is obviously of no concern in this discussion.

<sup>1</sup> Gray (p. 646) ascribes these two genera as well as *Suillus* to Micheli, but apparently erroneously so, unless other publications of Micheli's were available to him that are not known at the present day. In the *Nova Genera Plantarum*, there is no mention of such genera as *Pinuzza* and *Leccinum*, although the Italian words "pinuzzo" and "leccino" along with "porcino," "pinaccio," "pinarello" and many others are given as the common names of fleshy fungi ("leccino giallo" for an agaric apparently, and the others for "pinophilous boletes").



*Suillus* was to include those forms with collar (annulus) distinct and had one species, *luteus*; *Pinuzza* had a fibrous annulus and one species, *flava*. Since both of these species belong in the *Viscipelles* of Fries and Peck, or the genus *Ixocomus* Quélet (1888), both names have priority over *Ixocomus* and either might be selected for the species with viscid pileus, adnate to decurrent tubes and rather small, elliptical spores. It would seem that *Suillus* should be preferred because it has a tradition which *Pinuzza* lacks, even though it also has had a more varied history. So far as is known, the name *Pinuzza* was not used before Gray and otherwise is of very infrequent occurrence in the literature. In fact, it is very difficult to find the name in synonymy. On the other hand, *Suillus* is an ancient name. According to Pliny (77 A.D.), the Romans used it (not in a generic sense, of course) for what was apparently *Boletus edulis* and perhaps other *Boleti*, while calling *Amanita caesarea* by the name *Boletus*. Caesalpino (1583) and Porta (1592) used both words in the same manner. Micheli (1729) first used *Suillus* as a generic name, applying it to the *Boleti* and using *Boletus* as did Tournefort (1694 & 1700) for the morels and phalloids. He was followed by Haller (1742, and in part, 1768), Müller (1763) and Adanson (1763); Vaillant (1727) and Battarra (1755) used *Boletus* but not *Suillus*.

Up to this point, a majority had referred to the *Boleti* under the name *Suillus*, the notable exceptions being: Tournefort, who used *Fungus* for at least a part, and his follower, Vaillant; Dillenius (1719), who first used *Boletus* for this group and some of the polypores; and Battarra, who coined a new name, *Ceratomyces*. It was Linnaeus (1753) who definitely turned the tide away from *Suillus*, for which he substituted *Boletus* in Dillenius' sense, just as he changed the senses of all the names used by the Romans. Linnaeus was followed in this usage by: Schaeffer (1762-1774); Scopoli (1760 & 1772); Jacquin (1773-1778); Batsch (1783-1789), who, however, used the subgroup *Suilli* for the boletes; Bulliard<sup>2</sup> (1791-1812); Schrader<sup>2</sup> (1794), Persoon (1801) and

<sup>2</sup> Fries (1821, p. 386) and Bataille (1908) both stated that Bulliard and Schrader interpreted *Boletus* as the *Boleti* of the present day. Both workers, however, included the polypores in this genus, although they separated them in different subgroups.

others. Poiret (1806) resurrected Micheli's name *Suillus*<sup>3</sup> for the *Boleti* and one polyporaceous species, *betulinus* (see last sentence of footnote 2). Then Gray, as noted above, restricted *Suillus* to one group of the *Boleti* included in Fries' *Viscipelles* of *Boletus*, only to have it ignored by subsequent workers until Karsten in 1882 applied it in a still different sense, to make a new genus for the Friesian *Cariosi* (*cyanescens*, *castaneus*, etc.), the later genus *Gyroporus* of Quélet (1886).

*Leccinum*, used by Gray for species with no annulus, was necessarily a conglomerate genus, including the species: *aurantiacum* (with varieties *leucopodium* and *rufum*) and *scabrum* of the Friesian and Peckian *Versipelles* and the more recent genera *Krombholzia*, *Krombholziella* and *Trachypus*; *lactifluum* (= *B. granulatus*) and *piperatum* of the *Viscipelles* and genus *Ixocomus*; *subtomentosum* of the *Subtomentosi* and genus *Xerocomus*; *constrictum* (= *B. cyanescens*) of the *Cariosi* and genus *Gyroporus*; *edule* and *elephantinum* (= variety of *edule*) of the *Edules*, and *luridum* and *rubroalarium* (= *luridum*) of the *Luridi* and genus *Boletus*. With the exception of *piperatum*, the foregoing is the order in which the

<sup>3</sup> It is not a matter of great importance, but the situation may as well be clarified, especially since in the treatment of the Boletaceae in *North American Flora* 9: 154, 1910, the first synonym under the genus *Boletus* (Dill.) L. reads as follows: "*Suillus* Poir. in Lam. Encyc. 7: 496, 1806." In the first volume of the *Encyclopédie Méthodique*, Lamarck's genus *Agaricus* was tubular and included both the boletes and the polypores. Then Poiret, who prepared the material for the later volumes, inserted *Suillus* apparently as a genus, only to confuse the issue in a statement to be found below. The two pertinent paragraphs are given verbatim herewith:

"SUILLE. *Suillus* Genre de plantes acotylédones, de la famille des champignons, qui renferme un certain nombre d'espèces, d'une substance ordinairement ferme & coriace, munie d'un pédicule qui soutient un chapeau, dont la surface inférieure est munie de pores nombreux, très-sérres, alongés, tubulés, adhérens ensemble, mais faciles à détacher de la substance charnue qui leur sert de réceptacle. Ce dernier caractère est le seul qui les distingue des bolets (*boletus* Linn.; *agaricus* Lam.), la masse des tubes ne pouvant être, dans ceux-ci, séparée de la substance charnue.

"Il est aisé de reconnoître que les suilles, d'après ce caractère, ne sont qu'une division des bolets, & qu'ils ne peuvent pas en être séparées comme genre. Nous ne les présentons ici que parce qu'ils nous offriront l'occasion de rappeler plusieurs espèces qui n'ont pas été mentionnées à l'article AGARIC, dénomination qui avoit été adoptée par Tournefort, & que M. Lamarck a substituée à celle de *bolet* Linn. Nous nous bornerons cependant aux espèces les plus remarquables."

species were presented by Gray. As far as can be ascertained, the genus *Leccinum* has been used by no one else.

As suggested three paragraphs above, it is proposed to adopt *Suillus* Micheli ex S. F. Gray [type species—*S. luteus* (L. ex Fr.) S. F. Gray] for the Viscipelles of *Boletus* of Fries and Peck in place of *Ixocomus* Quélet. *Suillus* has priority over every other name for this group of Boleti and it is legitimate under the International Rules to select it even though Gray placed species to be included in this genus in two other genera. Furthermore, the establishment of *Suillus* (1821) in place of *Ixocomus* (1888) will obviate the raising of embarrassing questions such as why *Cricunopus* or *Rostkovites* (both Karsten, 1881) or *Viscipellis* Quélet (1886) should not supersede *Ixocomus* Quélet (1888), and also why *Suillus* Karsten (1882) in an entirely different sense (for the *Cariosi* of Fries and Peck) should not supersede *Gyroporus* Quélet (1886).

It is also proposed that *Leccinum* S. F. Gray [type species—*L. scabrum* (Bull. ex Fr.) S. F. Gray] be adopted for the Versipelles of Fries and Peck in place of *Trachypus* Bataille (1908). The name used for this group by many mycologists in Europe has been *Krombholzia* Karsten (1881). This name, however, was originally used by Ruprecht <sup>4</sup> (1842) for a member of the Festuceae of the Gramineae, and R. Maire (1937) in its place suggested *Krombholziella*, which, however, is antedated by *Trachypus*. To be sure, Gray had no such conception of the use of the name *Leccinum*, for in this genus he placed species now found in several of the newer genera, but it is proper arbitrarily to select the first two presented by Gray under that name. Furthermore, in view of the previous confusion and the as yet unaccomplished establishment of the genus *Trachypus* because of its recent proposal (cf. Snell, *loc. cit.*, 1941), a new name is not going to be greatly disturbing.

Since Gray used generic characters unacceptable today and accordingly made generic groupings which no one now would consider at all satisfactory, and especially since his genus *Leccinum* is so heterogeneous in the light of present-day understanding of its species, it may be objected that the use of any of Gray's boletaceous

<sup>4</sup> *Krombholzia* Rupr. ex Gal. in Bull. Acad. Brux. ix. II. 247 (1842), *nomen nudum*; ex Fournier in Bull. Soc. Bot. Belg. xv. 464 (1876).

genera is merely adding unnecessary confusion. On the other hand, these are times of change in mycology because of the discovery of new facts and the development of new taxonomic concepts, and one may as well unflinchingly make such changes as are necessary or desirable under the Rules and make them once and for all. Certainly, under the present Rules any changes made to Gray's genera are not going to be superseded, unless by special rulings. Further, in the Boletaceae, none of the more recent generic revisions has as yet been generally adopted in Europe, and in this country no revised scheme has had any vogue. Accordingly, a few generic changes at this time are not going to prove very disconcerting; it is believed that the suggested changes will lay more difficulties than they raise.

It is further proposed that *Versipellis* Quélet (1886), which antedates *Xerocomus* Quélet (1888), be considered a *nomen ambiguum*. All who have followed Fries and Peck and some who have modified the Friesian and Peckian schemes have used the term Versipelles for a tribe or group which includes the common species *versipellis* (or *floccopus* or *rufescens*), *scaber*, etc., the newer generic names for which are given above. It is believed that the use of the singular of this word for an entirely different group would accomplish no useful purpose and would only add confusion when it can easily be avoided.

Still another proposal involves a new genus. In the last few years, Murrill (1938, 1939 and 1940) has described from Florida six new species in *Gyroporus* (the *Cariosi* of Fries and Peck), in four of which some important characters are at variance with the usual European conceptions of the genus. These species all have solid stipes. Further, the tubes of the species are not free as typically in *Gyroporus*. More important, however, the spores of these species are white in deposit instead of yellow, and instead of being broadly oblong-elliptical in shape are narrowly ellipsoid or cylindrical, if not more or less subfusiform—3 to 4 times longer than broad as compared with 1.5 to 2.5 times longer for the species of *Gyroporus* as most commonly conceived. Accordingly, it would seem that these would be better placed in a new genus.

Two other species of Murrill's make the situation not quite as clear-cut as one might wish it. *G. rosealbus* and *G. umbrinisqua-*

*mosus* produce spore-deposits that are white or nearly white instead of yellow, and the stipe of the former is solid. Since, however, the spores are broadly elliptical, they belong in *Gyroporus*.

The proposed new genus is as follows:

**Leucogyroporus** gen. nov.

Pileo sicco, e subtomentoso glabro; carne alba, non cyanescenti; tubulis e subdecurrentibus adnexis, non libris, albis vel pallidis, non flavescentibus, poris parvis; stipite glabro, solido; sporis anguste ellipsoideis, subfusiformibus vel cylindricis, in pulvere albis vel ochraceo-albis.

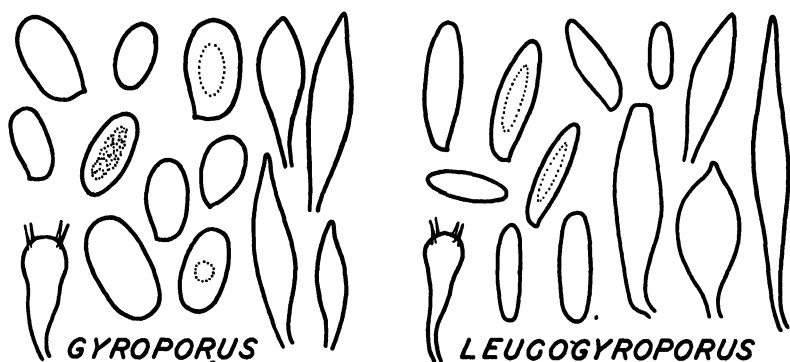


FIG. 1. Spores, cystidia and basidia of *Gyroporus* and *Leucogyroporus*. Spores  $\times 1000$ ; cystidia and basidia  $\times 500$ .

Carpophores gymnocarpic. Surface dry, glabrous, felted to subtomentose. Flesh white, not changing to blue. Tubes adnexed, adnate, depressed or decurrent, not becoming free; white or pallid at first, remaining so or becoming isabelline to pale ochraceous or even reddish-brown in one species, not becoming yellow; pores small to minute. Stipe glabrous, even, solid. Spores narrowly ellipsoid to more or less cylindrical or subfusiform, 3 to 4 times longer than broad, white to ochraceous-white in deposit. Cystidia fusiform to fusiform-clavate, hyaline.

TYPE SPECIES—*Gyroporus pisciodorus* Murrill

The following new combinations are made: **Leucogyroporus pisciodorus** (Murr.) Snell comb. nov., **L. stramineus** (Murr.) Snell comb. nov., **L. Rhoadsiae** (Murr.) Snell comb. nov., and **L. deflexus** (Murr.) Snell comb. nov.

While one is on the subject of new genera of the Boletaceae, attention may be called to Murrill's new genus *Frostiella* (1942), erected to include two species with slender and coarsely reticulated or lacerated stipe and with ornamented spores—*Boletus Russellii* Frost and *B. Betula* Schw. In Gilbert's arrangement, these two species were placed in Murrill's genus *Boletellus* along with *B. Ananas* (cf. Snell, 1941). In Murrill's scheme of the family, his new genus seems amply justified. Even in Gilbert's, there is much to be said for it, for either with or without two species added to *Boletellus* by the writer (*B. chrysenteroides* Snell and *B. subflavidus* Murrill—*loc. cit.*), the genus is more or less composite. Consideration has often been given to the splitting of *Boletellus* in the Gilbertian sense, but the temptation has been resisted in the interest of keeping down the number of genera with one or two species. Hence, for the time being at least, Murrill's *Frostiella* will not be added to a list of genera of the family already long and increased in this paper by one more new one.

#### SUMMARY

Since S. F. Gray's *Natural Arrangement of British Plants* has been found to be post-Friesian, it becomes desirable, if not necessary, to consider his generic names.

It is proposed to adopt *Suillus* Micheli ex S. F. Gray in place of *Ixocomus* Quélet, and *Leccinum* S. F. Gray in place of *Trachypus* Bataille.

It is also proposed to consider *Versipellis* Quélet a *nomen ambiguum* in order that it may not supersede *Xerocomus* Quélet, since the word Versipelles has long been associated with the *versipellis-scaber* group of species.

A new genus *Leucogyroporus* is proposed for four newly described Florida species originally placed in *Gyroporus* or the Friesian and Peckian *Cariosi* of *Boletus*, with tubes not free, stipe solid and spores narrowly elliptical and white or nearly white in deposit.

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# PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXXVII. PEZICULA PURPURASCENS

FRED J. SEAVER

(WITH 1 FIGURE)

The above named species was originally collected at Westchester, Pennsylvania, in July, 1888, and distributed in North American Fungi 2147. In working over the type material in The New York Botanical Garden, the writer was interested in noting a peculiar conidial stage associated with it, and possibly representing its conidial stage. The conidiophores resembled small asci and like the asci ruptured at the end permitting the four-celled conidium to emerge. This might be called an *Endoconidium* but, because of the close resemblance of the conidiophore to an ascus, the term **ascoconidiophore** is proposed, the conidium would then be an **ascoconidium**. Up to recently this species of *Pezicula* was apparently known only from the type collection in Pennsylvania.

In 1933, Dr. Theodore T. Ayers sent the writer a specimen collected by J. R. Hansbrough as *Dermatea purpurascens*, under which name it was originally described. Examination of this material on *Castanea dentata* showed the same ascus-like conidia found in the original collection made by Ellis, and since the two are constantly associated have good reason to assume that the two are organically connected.

This peculiar type of conidiophore is in itself sufficiently important to deserve special mention. Here we have a conidium which so closely simulates an ascus that the writer was at first led to wonder if there were not two ascomycetes associated. Careful examination, however, convinced us that the interesting structures were really conidiophores with the conidia produced internally. The ascoconidiophores are themselves pale brown, while the ascoconidia when released are nearly hyaline, or faintly smoky, and 3-septate, as are also the ascospores, but slightly different in form.

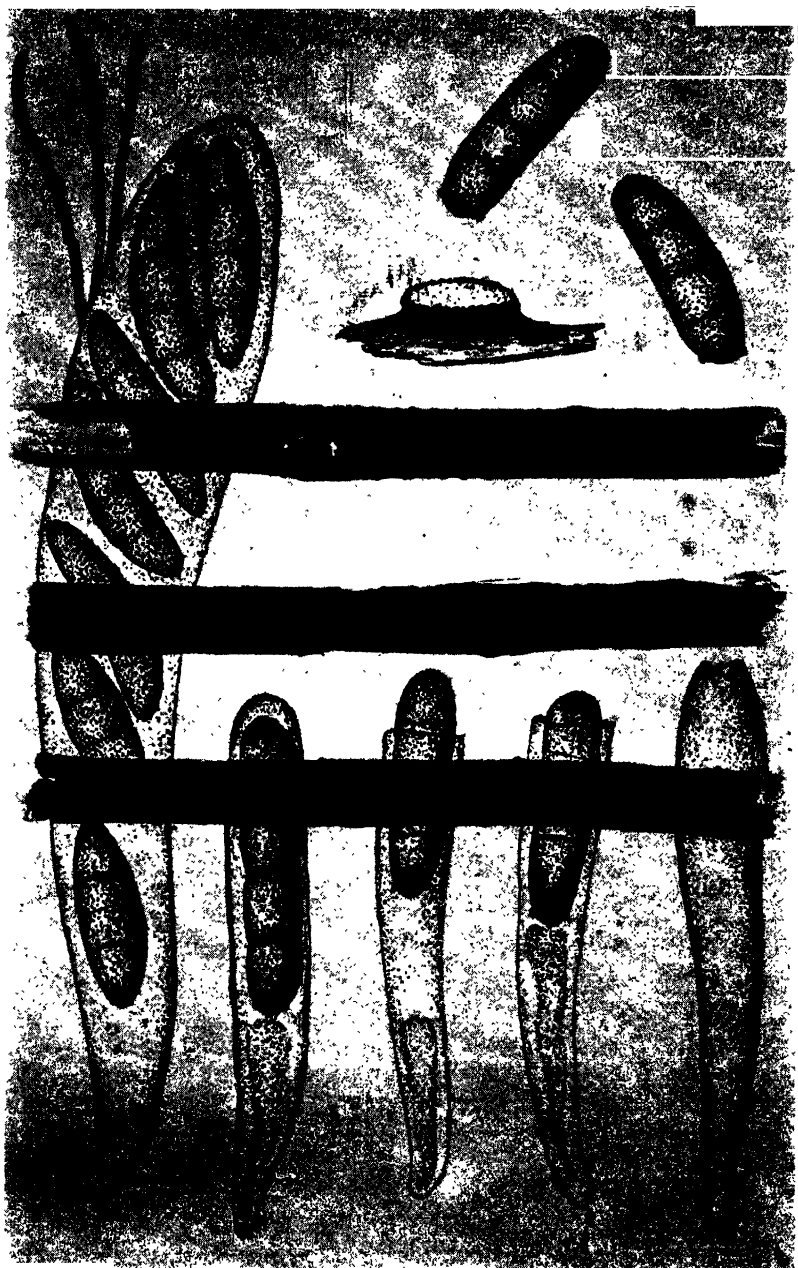


FIG. 1. *Peticularia purpurascens*.

We cannot, of course, claim that this is the conidial stage of the discomycete. However, it is remarkable that the two should be so closely associated in specimens collected more than forty years apart, the one in New Jersey and the other in Massachusetts. The conidia are produced in sori similar to those producing the apothecia and may precede them. Unfortunately the material is too old for cultural study, and the writer is presenting the facts as they are without attempting to explain them.

This fungus might be referred to the genus *Endoconidium* Prill. & Delac., but differs in that there is only a single 3-septate spore in each ascoconidium, and in that the ascoconidium is more ascus-like. It is here regarded as a distinct genus:

***Ascoconidium Castaneae* gen. et sp. nov.**

Conidiophoris clavatis, ascorum similibus, fuliginis,  $9-10 \times 30-40 \mu$ , monosporis; conidiis ellipsoideis, 3-septatis, subhyalinis.

On branches of *Castanea dentata* (Marsh.) Borkh. associated with *Pezicula purpurascens* (Ellis & Ev.) Seaver.

TYPE LOCALITY: Westchester, Pennsylvania.

DISTRIBUTION: Pennsylvania and Massachusetts.

***Pezicula purpurascens* (Ellis & Ev.) comb. nov.**

*Dermatea purpurascens* Ellis & Ev. Jour. Myc. 4: 100. 1888.

Apothecia scattered, erumpent, occurring singly or 2 or 3 crowded together, sessile or subsessile, externally reddish-purple, reaching a diameter of .75–1 mm.; hymenium plane or slightly concave, dirty-white becoming reddish-purple but lighter than the outside of the apothecium; asci cylindric-clavate, reaching a length of  $120-140 \mu$  and a diameter of  $25-30 \mu$ , 8-spored but some often undeveloped,  $8-11 \times 30-36 \mu$ , hyaline or nearly so, ellipsoid with the ends strongly narrowed, becoming distinctly 3-septate,  $9-11 \times 30-36 \mu$ ; paraphyses slender, slightly enlarged above, reaching a diameter of  $2-3 \mu$ , often slightly colored.

Conidia found associated with this species and possibly representing its perfect stage. Ascoconidiophores club-shaped reaching a length of  $90 \mu$  and a diameter of  $12 \mu$ , pale brown, containing ascoconidia; ascoconidia broad ellipsoid reaching a length of  $30-40 \mu$  and a diameter of  $9-10 \mu$  borne on slender stalk within the

conidiophore becoming disconnected, and finally discharged through the ruptured conidiophore, 3-septate, appearing brownish within the conidiophore but hyaline or subhyaline when discharged.

The exterior of the apothecium is clothed with a palisade of appressed, poorly developed hairs which are dilutely purplish. It is this character which has suggested the specific name.

On dead limbs of chestnut, *Castanea dentata* (Marsh.) Borkh.

TYPE LOCALITY: West Chester, Pennsylvania.

DISTRIBUTION: Pennsylvania and Massachusetts.

EXSICCATI: N. Am. Fungi 2147.

THE NEW YORK BOTANICAL GARDEN

#### EXPLANATION OF FIGURE

FIG. 1. *Pezicula purpurascens*. Photograph of chestnut branches bearing apothecia and conidia, about natural size. At the left, drawing of an ascus with spores and paraphyses. Above, drawing of one apothecium enlarged; also two ascoconidia. Below, *Ascoconidium Castaneae*. Several ascoconidiophores showing stages in the development and discharge of the ascoconidium. Photographed and drawn from type material collected at Westchester, Pennsylvania, in 1888.

# STUDIES IN THE GENUS TRICHOLOMA—I

WALKER R. ARDE, JR.

(WITH 21 FIGURES)

During the past fifteen years the writer has been collecting fungi, mostly the hymenomycetes, in Pennsylvania, New Jersey and the New England States. Seven hundred and fifty paintings have been made from fresh material, spore observations made and data taken.

During the first years, the author was fortunate in having the help of Prof. Charles Kauffman and of Prof. Henry Beardslee. Also many of the *Russula* paintings were sent to Dr. Rene Maire in Morocco for his opinion.

During all this time very few new species were found. However, many so called "new species" were found to be identical with Friesian species.

In order to come to a conclusion on many controversial species it has been necessary to look up illustrations of nearly all the early mycologists that Fries referred to. In doubtful cases Fries' opinion, as stated in his *Hymenomycetes of Europe*, has been adhered to.

The *Tricholomac* have been dealt with first as they constitute a particularly difficult genus. So far, twenty-eight different species of *Tricholoma* have been found. Of these, twelve have not been reported from America before as given below but some of them have been reported under other names by American mycologists. In such cases the American synonym is given. Exsiccata of many are preserved in the New York Botanical Garden.

## TRICHOLOMA QUINQUEPARTITUM Fries.

Agrees well with original figure *pl. 25* in *Hymenomycetes of Europe*.

Pileus 6 cm. broad, convex, umbonate (in some specimens), glabrous, *very viscid when wet*, lemon-yellow color with some

orange tints; lamellae adnexed, white, crowded, all lengths, 6 mm. broad; stipe tapering downward, ventricose in center, pallid with a faint yellow tint, crooked, *faintly discoloring, ferruginous where handled*; odor and taste farinaceous.

Solitary in birch and conifer woods at Moosehead Lake, Maine. Found on several occasions. Differs from *T. sejunctum* Fries in being viscid and in not having the pileus streaked with dark, fibrillose fibers. It nearly always has a crooked ventricose stem as Fries' illustration shows. New to America.

TRICHOLOMA ALBELLUM Fries (FIG. 3).

Pileus 5 to 8 cm. broad, hemispherical, then flattened, edge at first incurved, *striated with faint, fibrillose scales, often marked also with drop-like scales*, dry, pale fleshy-ochre color; lamellae emarginate, creamy-white to pale watery yellow, rather distant, brittle, thick at base; stipe short (5 cm.), thick (2 cm.), *usually with a thick, ovate bulb* that gradually merges into the stipe midway, *very firm*, chalky-white, *sordid-clay on handling*; odor strong, varying from nitrous, earthy, new-mown hay, etc.; taste mild; spores *minute*,  $4\frac{1}{2} \mu \times 3\frac{1}{2} \mu$ , white, nucleate.

Never in clusters as far as I have seen but usually gregarious. In coniferous woods at Valley Green, Penna. Also at Penn Valley 1934. Fries says in Hymenomycetes of Europe that there are two forms, one solitary as he found it and one caespitose which Sowerby described and which has not been found since. They seem like two different species to me. *T. albellum* and *T. gambosum* have often been confused. Fries says that *T. gambosum* always has an equal stem while *T. albellum* often has the base swollen by an ovate bulb. This is in contradiction to the name as *gambosum* means a swelled hoof. From Fries' earlier works it appears that what he first described as *gambosum* he later described as *T. albellum*. Apparently he later thought it was a form of *T. albellum* Sowerby. *T. gambosum* has more flesh-pink tones and always has an equal stem.

TRICHOLOMA LORICATUM Fries (FIG. 5).

Pileus large (9 cm.), convex-campanulate, then flattened, *with a thick, leather-like cuticle resembling parchment*, unpolished, greasy

when wet, livid-fuscon in center, pale yellow-green on edge, fading to dirty white; lamellae 7 cm. broad, adnate-emarginate, hardly crowded, very pale ochre; stipe 10 cm. long,  $2\frac{1}{2}$  cm. thick, equal, *hollow, fibrous, pale salmon color*; odor *spicy, disagreeable, like wild carrot*; taste somewhat farinaceous; spores white, smooth,  $5-6\ \mu \times 3\frac{1}{2}\ \mu$ , with an oil globule.

Found on several occasions growing in pairs, at Penn Valley, Pennsylvania, in frondose woods in October. This rare species has not been reported from America before. It has not been pictured by anyone as far as I know. The strong spicy odor makes it easy to identify. Hard's *pl. 63* as *T. saponaceum* looks like it. *T. saponaceum* Fries—its nearest neighbor is much smaller, has a short, tapering stipe, pileus polished and a soapy-farinaceous odor. Also the lamellae of *T. saponaceum* usually have a glaucous tinge.

#### TRICHOLOMA GUTTATUM Schaeffer (Stature of FIG. 8).

Pileus 6 cm. across, convex, edge somewhat incurved, *dry, somewhat squamose-scaly*, squamules often arranged in spot-like scales. Nearly cinnamon color (Ridgway), to vinaceous-drab, very firm; lamellae emarginate, 8 cm. broad, easily separating, close, dirty white color; stipe *solid, very firm*, naked (or a few fibrillose scales), bulbous, short (4 cm.), 2 cm. thick at base; odor none; taste at first little bitter and peppery, then mild; spores white, with an apiculus,  $7\ \mu \times 5\frac{1}{2}\ \mu$ , smooth.

Found growing solitary, at Penn Valley, Oct. 1933. Difficult to identify. *T. guttatum* is not well understood and is vaguely described. Fries says the specimens of Lasch showed the pileus to be more flocculose than granulose. Fries says it is cinnamon color.

#### TRICHOLOMA COLUMBETTA Fries f. *robusta* Sterbeeck.

Pileus at first *globular-convex*, edge incurved, *silky*, whitish, often with brick-red and grey spots; flesh thick; lamellae emarginate, 6 cm. broad, dirty cream color, brittle, often separating easily; stipe entirely bulbous, at first concolorous, very firm, solid; flesh or stipe inside slightly pink on cutting, in my specimens; odor none.

Grew in pairs at Penn Valley and Valley Green (coniferous woods), fall 1925.

## TRICHOLOMA SPERMATICUM Paulet (FIG. 10).

Pileus 9 cm. broad, convex-flattened, with a rounded umbus, edge incurved, chalky white, umbus little buff, not viscid, apparently hygrophanous; flesh snow-white, unchanging; lamellae notched and free, 8 mm. broad, close, thin, *somewhat ragged on the edge*, pale dirty cream-straw color; stipe long (9 cm.), thin (1 cm.), equal, solid, distinctly cartilaginous, little furfaceous near top, white mycelium at base; odor farinaceous-disagreeable and semen-like at the same time; taste first farinaceous then peppery; spores round to ovate-round, hyaline,  $6\frac{1}{2} \mu \times 5\frac{1}{2} \mu$ .

Growing in pairs, on ground, in frondose woods, Penn Valley. Not reported from America before to my knowledge.

## TRICHOLOMA INAMOENUM Fries (FIG. 12).

Pileus 5 cm. broad, thick, hemispherical-umbonate, silky-smooth, dry, dingy-white; flesh thick, pure-white; lamellae very broad toward stipe, *with a decurrent tooth distant*, thick shiny-white with a cream-flesh tint; stipe long (7 cm.), 12 mm. thick, equal, but with a slight knob that is buried, pure white, solid; odor not pronounced; taste strongly farinaceous; spores smooth,  $4\frac{1}{2} \mu \times 3\frac{1}{2} \mu$ .

Deeply imbedded in pine needles, Bryn Mawr. New to America.

## TRICHOLOMA BREVIPIES Bulliard.

Pileus 8 cm. broad, flat, with undulating-drooping edge, soft, chamois-like feeling, dry, creamy-white; lamellae *crowded*, creamy-yellow, emarginate-free, some forked and many shorter ones, 7 mm. broad, *they stop short of the stipe*; stipe short ( $2\frac{1}{2}$  cm.), knob-like on end, *tough due to outer fibrous coat*, concolorous, but *internally ropy and ferruginous tinted*, strongly attached; odor none; taste bitter in my specimens.

Found growing solitary on ground, in open woods, near Toronto, Canada. New to America. The outstanding feature (as Bulliard shows in his plate) is the short stipe that is ferruginous inside.

## TRICHOLOMA PORTENTOSUM Fries.

Pileus 7 cm. across, convex, firm, not viscid, ecru-drab (Ridg.), *streaked with black, fibrillose lines*, sometimes arranged in the form of scales; lamellae rounded, almost free, whitish at first, *then pale drab*; stipe *short, very firm*, solid, smooth, white inside and outside,



somewhat bulbous, deeply imbedded in soil, odor none; taste peppery (in my specimens).

Grew solitary, on the ground, in frondose woods. Fries' *Pl. 24* in *Hymenomycetes* shows colors well. It is a fuliginous-livid color.

**TRICHOLOMA PUTIDUM** Fries (FIG. 15).

Pileus 4 cm. broad, hemispherical, thin, flaccid, *soft, chamois-like feeling*, pale greyish-olive (deep olive-buff) Ridg., hygrophanous, somewhat hoary; lamellae also olive-buff, sinuate-adnate, *distant*, broad (6 mm.); stipe 4 cm. long, 6 mm. thick, equal, fibrous outer coat, *often flattened*; odor very disagreeable (when old); spores pip-shaped,  $7\ \mu \times 3\frac{1}{2}\ \mu$ .

Found growing solitary on buried wood-chips, at base of rotten stump, at Valley Green, in coniferous woods. The cap is somewhat velvety. Resembles Cooke's *Pl. 601* of *Naucoria centunculus*. New to America.

**TRICHOLOMA LURIDUM** Schaeffer (Stature of FIG. 17).

Synonym—*Tricholoma duracinum* Cooke.

Pileus  $4\frac{1}{2}$  cm. broad, convex, *irregular and lobed*, edge incurved, silky, somewhat fibrillose, serpentine-green (Webster's Dict.), and pale testaceous, becoming streaked with cinereous; lamellae emarginate, crowded, pale olive-grey (griseus—Sacc.), edge white-fimbriate, all lengths; stipe short (4 cm.), thicker and curved at base (2 cm.), solid, cartilaginous, fibrillose, with rusty-brown stains; odor earthy pleasant; taste mild (but a little warm after-taste); spores,  $6\frac{1}{2}\ \mu \times 5\ \mu$ , greenish-brown under the microscope.

Grew solitary in frondose woods, Penn Valley, rare. New to America. Cooke's *Pl. 214* Ill. of *British Fungi* shows it well.

**Tricholoma cuneifoloides** Arde, sp. nov. (FIG. 20).

Pileus unciam latus, convexo-obtus, isabellinus (novus solanum tuberosum color), laevi-punctato vel virgato cum minima-squamae, *glutinosus*; lamellae cuneus-formus, albis; stipe albis, levis, cuticula cartilaginea,  $2\frac{1}{2}$  cm. longus, sporis levis, globus, albis,  $5\frac{1}{2}\ \mu$ .

With *T. cuneifolium* Fries it is close but differs in the very viscid pileus.

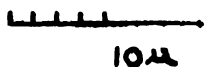
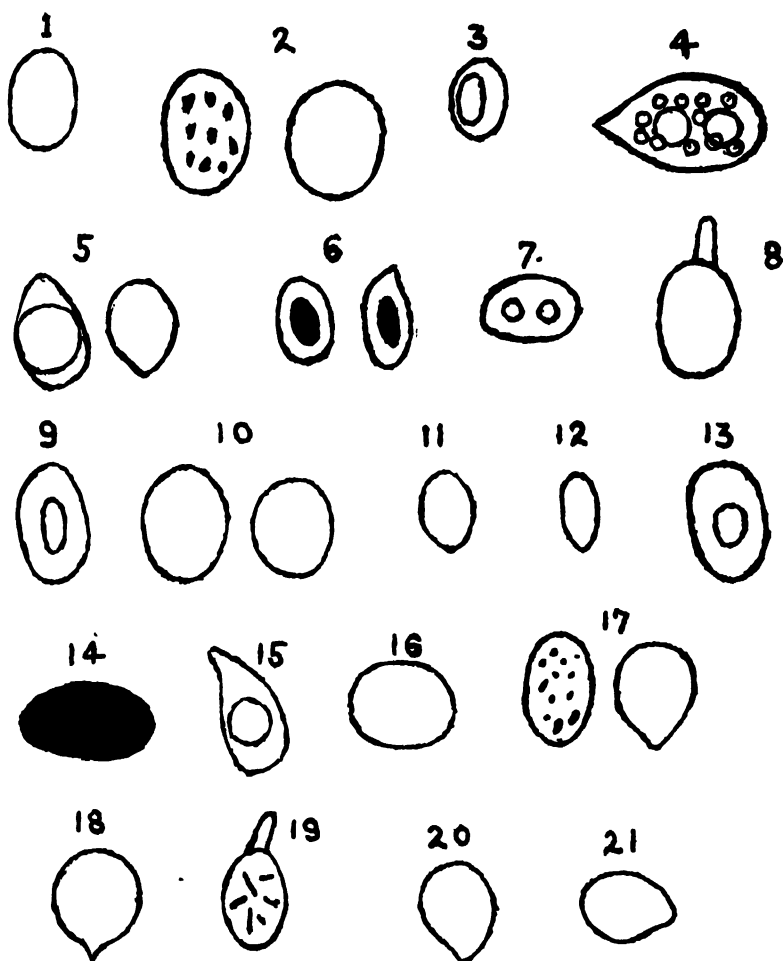


FIG. 1, *Tricholoma flavobrunneum*; 2, *T. equestre*; 3, *T. albellum*; 4, *T. sulphurcum*; 5, *T. loricatum*; 6, *T. saponaceum*; 7, *T. amethystinum*; 8, *T. guttatum*; 9, *T. panacolum*; 10, *T. spermaticum*; 11, *T. album*; 12, *T. inamocnum*; 13, *T. argyraceum*; 14, *T. virgatum*; 15, *T. putidum*; 16, *T. rutilans*; 17, *T. luridum*; 18, *T. cinerascens*; 19, *T. acerbum*; 20, *T. cuneifoloides*; 21, *T. subsejunctum*.

## TRICHOLOMA VIRGATUM Fries (FIG. 14).

Pileus 5 cm. broad, convex-hemispherical, thick, smoke-grey (Ridg.), *densely virgate with small, fibrillose scales*, dry; flesh thick, white, but *soon moddled grey*; lamellae sinuate, not as thick as the pileus (5 mm.), close, *smoke-grey*, darker on the edge, shorter ones; stipe equal but twisted, 5 cm. long, 5 mm. broad, silky-fibrillose (bark-like), also pale, smoke-grey, solid, little pink at base; odor strongly farinaceous; taste *very bitter*; spores elliptical, smooth,  $8 \times 5 \mu$ , purple-brown under the microscope.

Found growing solitary on a bank in coniferous woods. Seems close to *T. murinaceum* Bulliard but that species is not definitely said to have a bitter taste.

## TRICHOLOMA AMETHYSTINUM Scopoli (FIG. 7).

Pileus 6 cm. broad, convex-plane, mottled, color *lateritius* (Sacc.), with azure-blue spots, edge pale glaucous-cream, hardly viscid; lamellate rounded-adnexed, ventricose distinct, rather distant, soft, watery, cream-flesh color; stipe *very fragile, soon hollow*, fibrous (breaking in shreds), pure-white, but sordid on handling; odor and taste mild; spores white, smooth, oval,  $5\frac{1}{2} \mu \times 3 \mu$ , two guttate.

Found growing solitary at Penn Valley. Rare. Not well known. Fries seems to have confused it with *T. lividius* which is ash color. This is amethyst color.

## TRICHOLOMA SULPHUREUM Bulliard (FIG. 4).

Synonym—*Tricholoma chrysenteroides* Peck.

Pileus 4 cm. broad, campanulate, pale buff-yellow, unpolished; lamellae adnate, pallid, 6 mm. broad, close; stipe equal, *tortuous*, roapy, sulphur yellow (inside and outside); odor farinaceous; taste almond; spores almond-shape, sculptured,  $9 \times 5 \mu$ .

After examining Bulliard's *Pl. 168* of the above I see no reason why *T. chrysenteroides* Peck is not the same.

Just a word concerning some other difficult species that have been found here.

## TRICHOLOMA ACERBUM Bulliard (FIG. 19).

Exactly resembles Bulliard's *Pl. 571* of same. It grows in clusters, has large thick caps, buckthorn-brown (Ridg.) with center vinaceous-red. Edge of cap incurved. Lamellae *very narrow*, sulphur-yellow mycelium at base of stipe; odor strong, fungus-like, taste bitter.

## TRICHOLOMA CINERASCENS Bulliard (FIG. 18).

Illustrations misleading. Boudier's *Pl. 29* (*Icones Mycologicae*) shows it best. Pileus is pale ochre, dry, with a soft feeling, very tough at first but quite brittle on drying, edge turned up somewhat and undulating; lamellae attenuated at both ends, crowded, cream-straw color; odor strong (horse-radish); taste mild to slightly bitter; spores globose, white, smooth,  $5\ \mu$  (again  $5 \times 3\ \mu$ ).

Grows in clusters on the ground in the spring.

## TRICHOLOMA ALBUM Fries (FIG. 11).

My specimens resembled Kauffman's *Pl. 151* (of *T. acerbum*). Pileus convex-gibbous, thick in center, ivory-soap color, somewhat hoary and mottled, not viscid; lamellae very crowded, dirty-white; stipe with an ovate-bulbous base, short; odor none; taste farinaceous at first, then sharp or sharp-bitter; spores minute,  $5 \times 3\ \mu$ , smooth.

## TRICHOLOMA SAPONACEUM Fries (FIG. 6).

Stature of figure 6 but with a thinner stem. Pileus polished, pale fuscous, colors often stippled edge pale olive, semiviscid; lamellae, ventricose, cream color with a glaucous tinge, stipe short, white but with a flesh tint inside; taste farinaceous; odor soapy as in a laundry; spores white with a pink nucleus,  $4 \times 3\ \mu$ .

Common here after frosts.

The author is indebted to Dr. Seaver for his encouraging hand and for placing the very complete library of the New York Botanical Garden at his disposal.

302 NORTH 40TH STREET,  
PHILADELPHIA, PA.

# CHROMOBLASTOMYCOSIS <sup>1</sup>

A. L. CARRIÓN

(WITH 7 FIGURES)

*Definition.* Chromoblastomycosis is a chronic, infectious, apparently non-contagious, granulomatous dermatosis which is usually confined to an exposed area of the skin and may be caused by different but closely related dematiaceous fungi.

*Geographic distribution.* The disease was discovered by A. Pedroso, of Brazil, in 1911 (1), but the first case appearing in the literature occurred in Boston and was published by Medlar and Lane in 1915 (2, 3). Since that time at least one hundred authentic cases of chromoblastomycosis have been recognized throughout the world. The records would point to Brazil and Puerto Rico as the most heavily infected foci in existence, but the true incidence of this disease will not be known until the medical profession in different countries becomes better acquainted with the pathologic process and with the methods of diagnosis.

*Etiologic factors.* Chromoblastomycosis is most common during the period of active adult life; the higher incidence falls upon males and there seems to be no race immunity. As a rule, the patients give a history of being farm laborers who work barefooted most of the time. Transmission from man to man has never been recorded so far. Apparently, the fungus is present in the soil and individuals who are susceptible contract the infection through some unimportant abrasion of the skin.

*Clinical aspects.* The disease usually starts as a small, warty growth in some part of the foot, whence it extends upward through the development of satellite lesions. The course of the pathologic process is extremely slow, the duration at the time of examination often having been ten or twelve years.

An advanced case of chromoblastomycosis offers a most extraordinary dermatological picture (FIG. 1). The lesions occur in

<sup>1</sup> This study was made possible by a grant from the Bailey K. Ashford Fund.

great numbers and there is usually a certain degree of elephantiasis of the affected limb. The morphology of the lesions is extremely varied. Some of them consist of hard, elevated, variously sized, dull-pink or violaceous nodules, the surface of which is often irregular, verrucous and scaly. Larger lesions take the form of markedly prominent, sessile or pedunculated, cauliflower-like tumors. Superficially, these tumors are covered with a thick layer of hyperkeratotic epithelium which often falls off, exposing large numbers of pink papillomata. In a third type of lesion, the pathologic process forms moderately elevated, dull-red, scaly patches or plaques. Some of these plaques have a flat surface and may show exaggeration of the lines of cleavage of the skin; others become irregular due to the development, within the plaque, of papillomatous or nodular efflorescences, and still others, tend to heal centrally with the production of profuse scarring, the borders remaining active. Finally, there is a fourth type of lesion consisting of discrete or diffuse, hyperkeratotic growths that are purely verrucous in character.

The lesions of chromoblastomycosis are easily traumatized, they bleed readily, they may be complicated with bacterial infection and ulceration, and their surface often shows crusting and epidermal debris. Subjectively, pruritus is frequently an important symptom. Some patients complain of pain and, in advanced cases, there is partial incapacity for work. The deeper tissues are not usually involved, although there is one instance in which the bones of the leg were presumably affected. The lymphatic glands, draining the diseased focus, may participate in the process, but this is not the rule. However, adenitis due to bacterial complications, occurs frequently in patients with chromoblastomycosis. Metastases through the blood stream appear to be extremely rare, but there is no question that they can be produced (4). Finally, no systemic symptoms have yet been recorded for this disease.

It should be emphasized that the clinical picture just given is that of a well-developed, typical case of chromoblastomycosis. This picture is subject to variation. An early infection, one which has lasted for two or three years, for example, may consist of a single or a few verrucous growths, nodules or patches, which may not be specifically characteristic of chromoblastomycosis. On the



FIG. 1. Chromoblastomycosis in a male, white, Puerto Rican farm laborer, who contracted the infection fifteen years prior to examination while working barefooted in a coffee plantation.







other hand, in certain late infections, the lesions have become stationary before extending to any considerable degree. In such instances there may be found one or more ulcerated nodules, a papillomatous patch or a pseudo-ulcer with a depressed central area of hard, fibrotic scar tissue surrounded by an elevated, granulomatous growth.

Location may also influence the clinical picture. The large cauliflower-like tumors already described occur characteristically on the foot and lower leg. As a rule, the higher a lesion is located on the extremity, the less it will be elevated above the surrounding skin. Consequently, on the upper leg and thigh, nodules and plaques tend to predominate. Lesions of purely verrucous type are most frequently encountered on the foot, especially toward the borders and on the sole. Chromoblastomycosis is not nearly as frequent on the upper as on the lower extremities and the tumor lesions at the former location have never been as large as those often noted on the legs and feet. Otherwise the eruption is similar in both regions. Infections of the face have always been small and of the plaque type.

The species of fungus causing the infection does not seem to have much influence on the clinical picture. A possible exception was a Puerto Rican case in which the disease was confined to an upper limb and the lesions consisted of extensive, diffuse, even areas of infiltration with some papillomata on the hand and without tumors or nodules (5). This was the case produced by *Fonsecaea compactum*.

*Histopathology.* Histopathologically, chromoblastomycosis is a typical infectious granuloma. The lesions affect the epidermis, the cutis and the subcutaneous tissues and they tend to develop toward the surface with very little disturbance of the deeper structures. Microscopic examination reveals a dense cellular infiltration which includes lymphocytes, plasma cells, polymorphonuclears, eosinophiles, epithelioid cells and occasional giant cells of the Langhan's type. The pathologic reaction may be focal or diffuse; in places, it is distinctly tuberculoid; there is marked capillary engorgement as well as edema of the tissues and, not infrequently, microscopic abscesses. A constant feature of chromoblastomycosis is the development of an intense fibrosis which tends to wall off the infected

foci. The parasites are observed either within the giant cells or free in the tissues as spherical bodies measuring about 12 microns in diameter. These bodies, or sclerotic cells as they are often called, possess a dark, thick membrane and they often show internal septation. Their protoplasm is olivaceous and granular. In the epidermis there is usually a pronounced hyperkeratosis and acanthosis with the hypertrophic rete layer often forming irregular and interlacing epithelial columns which may extend deeply into the corium (FIG. 2).

*Diagnosis.* There are four essential elements of diagnosis in chromoblastomycosis. First among these is, of course, the clinical picture. This may be so characteristic that a mere look at the patient has often led to the correct diagnosis. However, there are other diseases, such as leprosy, syphilis, tuberculosis, mossy foot, etc., with which chromoblastomycosis might be confused and, consequently, laboratory investigations should always follow clinical inspection. It is worth mentioning that we have seen exceptional cases in which the eruption was as extensive and as typical as in any good case of chromoblastomycosis and, yet, it was impossible to demonstrate the presence of an etiologic agent of any sort. Whether these represent cured cases of the disease or some other infection of obscure etiology, it has been impossible to determine so far.

The second diagnostic element is the presence of typical sclerotic cells in the epidermal debris obtained by scraping the lesions. This is ascertained through microscopic examination of the material after mounting in a 40 per cent solution of potassium hydroxide (FIG. 3). Diagnosis should be verified further with a biopsy showing the characteristic histopathologic changes and the presence of the parasite and, finally, with the identification of the causative fungus in cultures from the scrapings or infected tissues.

*Mycology.* We do not propose to discuss here in full what is known about the fungi of chromoblastomycosis. It is our only purpose to focus the subject broadly and to present a brief summary of its fundamental highlights.

Repeated observations on a large number of isolates from cases of chromoblastomycosis in different parts of the World indicate that sporulation in this pathogenic group may be of three distinct



FIG. 2. Histopathologic sections of a lesion of chromoblastomycosis showing, at "a," epidermal changes and granulomatous infiltration of the dermis, and at "b," parasitic cells (so-called sclerotic cells) within a giant cell. Note internal septation in one of the fungus cells.

types. One of these types is the *Hormodendrum* (*Cladosporium*), in which the conidia are produced acrogenously in arborescent chains on the mycelial branches (FIG. 4: *a* and *b*). In the second, or *Phialophora* type, the sporulation is semi-endogenous in nature. The conidiophore is a flask-shaped cell and the spores bud out in succession from the constricted portion of the cell into an adjacent cup where they are often glued together forming characteristic spherical masses (FIG. 4: *c* and *d*). Finally, the *Acrotheca* method of sporulation is characterized by a specialized conidiophore consisting of a more or less extensive, straight or irregular, hyperpigmented, sometimes swollen hyphal segment which may be disposed terminally, intercalarily, or as a lateral branch. A conspicuous feature of this conidiophore is the presence throughout its surface of a large number of tiny, truncate, conical processes, to which the exogenous spores are united and which give to the fruiting structure a very characteristic verrucous appearance. Some of these conidiophores do not extend very much in length, but take the form of a short, swollen, irregular, warty growth. In certain strains in which this method of sporulation has reached its highest degree of development, the conidia are borne singly and only occasionally are secondary spores produced, forming chains of two (FIG. 4: *e* and *f*). In other specimens, however, spore heads of the *Acrotheca* type may show a greater tendency to chain formation.

A few of the fungi of chromoblastomycosis would seem to sporulate exclusively by one of the above methods. This is true of the species known as *Phialophora verrucosa* Medlar 1915 (6), in which the conidia are borne semi-endogenously in the form already described (FIG. 4: *c* and *d*). This is also true of a *Hormodendrum* species recently isolated by J. A. O'Daly<sup>2</sup> in a Venezuelan case. In this *Hormodendrum* we have been unable to find the *Phialophora* or the *Acrotheca*-like sporulations (FIG. 4: *b*). In most of the fungi of chromoblastomycosis, however, the three methods of sporulation, or at least two of them, occur simultaneously in the individual isolates (7). The organisms behaving in this manner

<sup>2</sup> Personal communication to the author. Doctor J. A. O'Daly kindly sent us a culture of this organism for study. As far as we know, the fungus has not been described as yet.

have been classed in two different species of the genus *Fonsecaea*, namely, *F. Pedrosoi* (Brumpt) Negroni, 1936, emend (8) and *F. compactum* Carrión, 1935, emend 1940 (5, 7). *Fonsecaea compactum* is represented by only one isolate discovered in Puerto Rico a few years ago. On the other hand, *Fonsecaea Pedrosoi* constitutes the vast majority of the fungi of chromoblastomycosis.

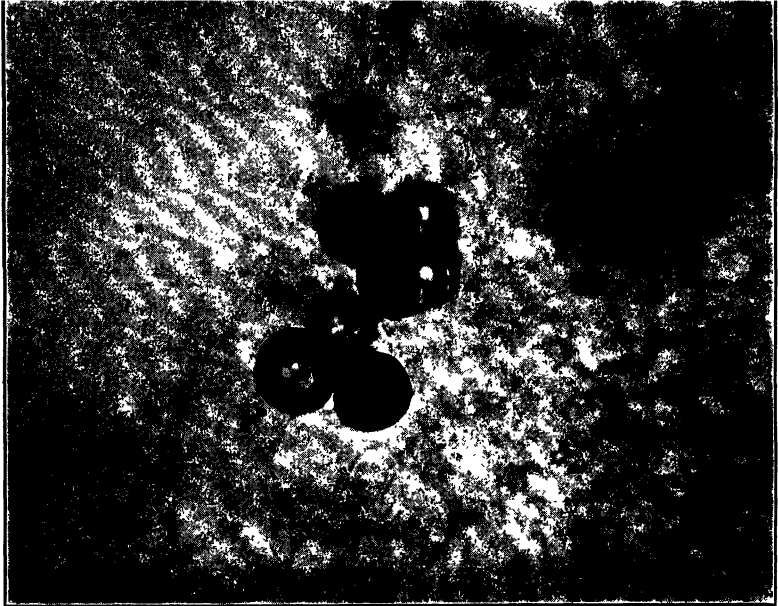


FIG. 3. Typical fungus cells found in the epidermal debris in a lesion of chromoblastomycosis.

The different types of sporulation characteristic of *Fonsecaea Pedrosoi* do not occur in the same proportions in all the strains of that species. In order to avoid confusion, therefore, it has been necessary to subdivide the group into a number of varieties in accordance with the predominant method of sporulation (7). *Fonsecaea Pedrosoi typicus* corresponds morphologically with Brumpt's original description of the fungus (10). Here the *Acrotheca*-like sporulation reaches its highest degree of development as to both quality and abundance. In members of this variety, the *Hormodendrum* heads may be scant, abnormal or depauperate.

The *Phialophora* cups are also very rare or missing. It would seem that both the *Hormodendrum* and the *Phialophora* methods of sporulation are becoming extinct in *F. Pedrosoi typicus* (FIG. 5: a to f).

In the second variety of *Pedrosoi*, namely, *Cladosporioides*, there is a similar situation, except that *Hormodendrum* (*Cladosporium*) is here the predominant character. In certain specimens of this variety, it is extremely hard to find sporulation of the *Acrotheca* and *Phialophora* types. In this instance it would seem that the *Acrotheca* and *Phialophora* methods are becoming extinct (FIG. 5: g, h, i).

In a third variety, *Phialophorica*, the *Phialophora* method is the preponderant. The only known isolate of this variety, originally described as *Phialophora macrospora*, produces typical spore heads of the *Acrotheca* type, while the *Hormodendrum* has become apparently extinct (FIG. 6).

Finally, the variety *F. Pedrosoi communis* reveals the three methods of sporulation in more or less conspicuous abundance. *Pedrosoi communis* includes a large number of intergrading forms which represent connecting links among the other three varieties (FIG. 5: j, k, l).

According to these observations it would seem that the fungi of chromoblastomycosis have all a common origin, namely, the variety *F. Pedrosoi communis*, which possesses the three methods of sporulation. Following different lines of evolution, certain strains of this group have gradually lost their ability to sporulate by any one or two of these methods. Thus, in the species *Phialophora verrucosa*, the *Phialophora* is the only method retained. It becomes evident, moreover, that the variety *F. Pedrosoi Phialophorica* represents a transition between the original group *F. Pedrosoi communis* and *Phialophora verrucosa*. Similarly, in the *Hormodendrum* species from Venezuela (O'Daly), only the *Hormodendrum* type has been retained, the variety *F. Pedrosoi Cladosporioides* representing the transitional group in this instance. Up to the present time, none of the fungi of chromoblastomycosis have been found to sporulate exclusively by the *Acrotheca* method, but we should not be surprised if, in the future, new isolates are discovered in which this method is the only one observed. The specimen de-

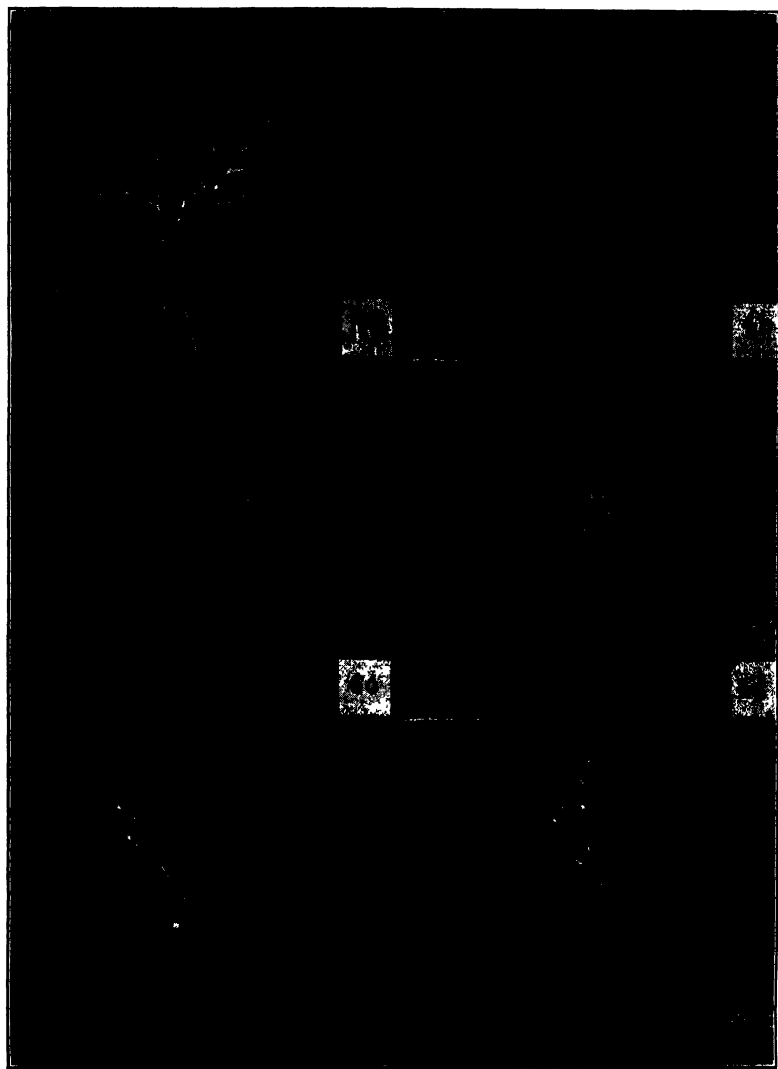


FIG. 4. Different methods of sporulation noted in fungi of chromoblastomycosis: *a*, *Hormodendrum* sporulation in a specimen of *Fonsecaea Pedrosoi communis* isolated from a case of chromoblastomycosis in the Dominican Republic; *b*, typical spore head in a *Hormodendrum* species isolated from a Venezuelan case; *c* and *d*, semi-endogenous sporulation in *Phialophora verrucosa* (Uruguayan isolate); *e*, *Acrotheca* type of sporulation in *Fonsecaea Pedrosoi communis* (Philadelphia case); *f*, *Acrotheca*-like sporulation in a Brazilian isolate of *Fonsecaea Pedrosoi typicus* (the so-called *Hormodendroides Pedrosoi*).



scribed as *Botrytoides monophora* (15) comes very close to fulfilling this condition (FIG. 7).

The classification of the fungus *Fonsecaea Pedrosoi* with its complicated morphology has been a much debated subject. The differences of opinion have centered essentially on two questions: 1. Are we dealing with only one species, namely, *Pedrosoi*, or with several? 2. Under what genus should *Pedrosoi* be placed?

Different varieties of *Fonsecaea Pedrosoi* have been repeatedly described as independent species by many investigators who have misinterpreted or over-emphasized the importance of one or another of the morphologic features of that fungus. Consequently, a review of the literature on the mycology of chromoblastomycosis will reveal a large number of specific names given to individual isolates which, apparently, did not correspond to the original description of *Pedrosoi* (10). However, after many years of careful and patient work, it has been demonstrated: (a) that the fungi described under such names have all a common tendency to sporulate by the three methods characteristic of *Pedrosoi* and cannot be considered as independent species; (b) that the only differences existing among these organisms lie in the comparative proportions in which these methods occur; and, finally, that these differences are quantitative rather than qualitative and, therefore, the only subdivision possible in this group should fall in the rank of varieties (7).

The second point of debate about the species *Pedrosoi* has been its proper generic name. As already stated, most of the names proposed for this species in the past have fallen into synonymy. However, there is still difference of opinion as to whether the fungus in question should be classed among the *Hormodendrum*s, the *Phialophora*s or the *Fonsecaea*s.

Shall *Hormodendrum* be retained? *Hormodendrum* is supported by the rule of priority and by the fact that a large number of isolates of the varieties *Cladosporioides* and *communis* present the *Hormodendrum* sporulation as an outstanding or, at least, a conspicuous character. On the other hand, there are fundamental objections to the use of that name. In the first place, the genus *Hormodendrum* would not admit certain isolates of the varieties *typicus* and *Phialophorica* because, in these isolates, the *Hormo-*

*dendrum* sporulation has become more or less obsolete while other methods of reproduction, typical of other well established genera, predominate. In the second place, experience has shown that the application of the name *Hormodendrum* to the species *Pedrosoi* is responsible for most of the confusion that has hitherto existed among the fungi of chromoblastomycosis. It is the objection to this name that has moved such a large group of investigators to place this fungus in so many other genera, leading to the long list of synonyms found in the literature. When Ota (11) and Langeron (12) erroneously placed *Pedrosoi* among the Trichosporiums, they were evidently impressed by the *Acrotheca*-like clusters, which were mistaken for *Trichosporium*, and they paid little or no attention to the scant and depauperate *Hormodendrum* sporulation noted in their cultures. Similarly, the generic names *Acrotheca* (13), *Gomphinarina* (14), *Botrytoides* (15) and *Hormodendroides* (15) have been applied to the species *Pedrosoi* by other well-known investigators who also placed the emphasis on the spore clusters of *Acrotheca* type, although they recognized the presence of *Hormodendrum* sporulation. In all these instances, it is clear that the authors were dealing with specimens of *Fonsecaea Pedrosoi typicus*. Even Brumpt, who is the author of the species *Pedrosoi*, and who called it a *Hormodendrum* in his original description in 1922 (10), was forced to admit later that the *Hormodendrum* sporulation was not the important character in the fungus he had studied (16).

Other workers have emphasized the importance of the semi-endogenous sporulation observed in *Pedrosoi* and have proposed two additional generic denominations for this species, namely, *Phialoconidiophora* (15) and *Phialophora* (17). These authors, too, have considered the *Hormodendrum* sporulation a feature of secondary importance. Finally, it is evident that Negroni, of Buenos Aires, had the same point of view when he called the fungus a *Fonsecaea* (8).

Summing up the situation, here are eight different generic names applied to one and the same species by a dozen different investigators who think that this fungus should not fall among the *Hormodendrum*s. Indeed, this is confusion. On the basis of this experience and in compliance with one of the most essential

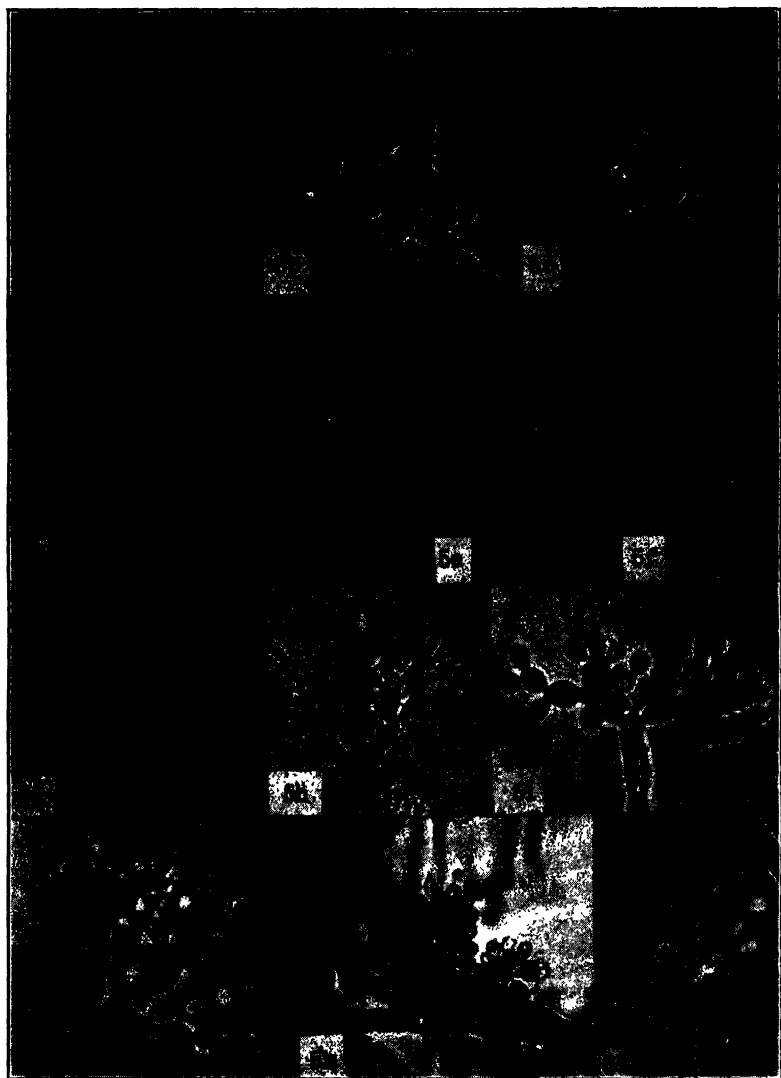


FIG. 5. *a, b* and *c*, *Acrotheca*-like, *Hormodendrum* and *Phialophora* types of sporulation in a South American isolate of *Fonsecaea Pedrosoi typicus* (the so-called *Botrytoides monophora*); *d, e* and *f*, the three types of sporulation in another South American isolate of the variety *typicus* (the so-called *Hormodendroides Pedrosoi*); *g, h* and *i*, triple sporulation in a South American strain, *Fonsecaea Pedrosoi Cladosporioides* (the so-called *Phialoconidiophora Guggenheimia*); *j, k* and *l*, sporulation of the three types in a Puerto Rican isolate of the variety *F. Pedrosoi communis*.

principles of nomenclature, which is "to avoid or reject the use of . . . names which may cause error or ambiguity or throw science into confusion" (18), the generic name *Hormodendrum* should be eliminated in this case.

Shall it be *Phialophora*? In the present state of our knowledge, the inclusion of *Pedrosoi* in the genus *Phialophora* would be objectionable for reasons fundamentally similar to those given against

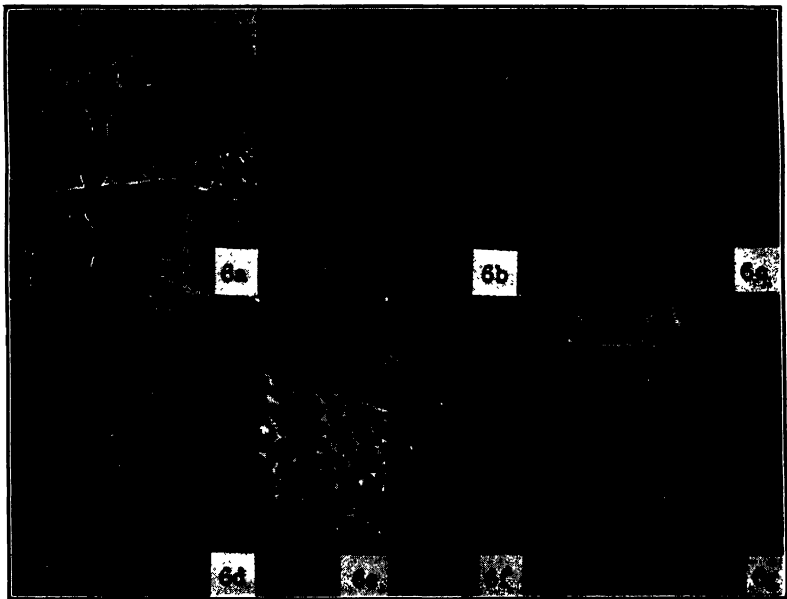


FIG. 6. The only known isolate of *Fonsecaea Pedrosoi* *Phialophorica* (the so-called *Phialophora macrospora*) obtained from a South American case. Note the typical sporulation of *Phialophora* in "a," and "b," and the *Acrotheca*-like sporulation in "c," "d," "e," "f," and "g."

*Hormodendrum*. Indeed, *Phialophora* would be more confusing than *Hormodendrum*. Among the numerous specimens of *Pedrosoi* so far isolated and studied, there is only one in which the *Phialophora* sporulation predominates; in all the rest, there is an overwhelming preponderance of either the *Hormodendrum* or the *Acrotheca* methods of reproduction. Under such circumstances, *Phialophora* would be a poor substitute for *Hormodendrum*. A change in nomenclature is not justified unless the new name has substantial advantage over the old.

Why *Fonsecaea*? For several years we used consistently the binomial *Hormodendrum Pedrosoi*. At the present time we are calling this fungus a *Fonsecaea*, not because we like *Fonsecaea* better, but because we feel that, using this name, the busy students in medical mycology can work more effectively, lose less time and understand each other better. Notwithstanding this, if the men working in this field should get together, discuss and come to an

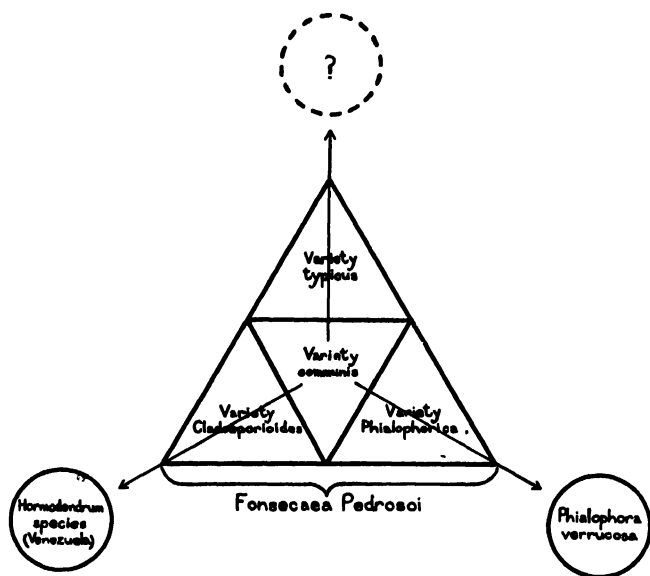


FIG. 7. Diagram showing apparent interrelations among certain fungi of chromoblastomycosis. The large triangle represents *Fonsecaea Pedrosoi*, which covers most of the fungi isolated from that disease. The included smaller triangles represent the four varieties which make up the species *Pedrosoi*. The arrows indicate different lines of evolution suggested. The circles represent independent species either real or potential. In *Fonsecaea Pedrosoi*, the variety *communis*, which possesses the three types of sporulation—*Cladosporium*, *Phialophora* and *Acrotheca*,—appears to be the common origin of all the other forms. The varieties *Cladosporioides*, *typicus* and *Phialophorica* show, respectively, a marked predominance of the *Cladosporium*, *Acrotheca* or *Phialophora* sporulations with a corresponding reduction, in each case, of the other two methods of reproduction. In the species *Phialophora verrucosa* and in the *Hormodendrum* isolate from Venezuela (see circles), the *Phialophora* and the *Cladosporium*, respectively, have become the exclusive methods of reproduction. The broken-line circle would represent the presumptive existence of other parasites sporulating exclusively by the *Acrotheca* method.

agreement on this point of nomenclature, we would be glad to abide by the decision of the group, no matter what that decision might be. Up to the present time, however, the more authoritative mycologists have failed to agree on this important subject. Under such circumstances, and with a purely compromising spirit, we have accepted the generic name *Fonsecaea* as a good substitute for *Hormodendrum* in the case of *Pedrosoi*. *Fonsecaea* is a legitimately created and comprehensive genus which covers, without strain, all the varieties of the species *Pedrosoi*. Its creation has solved a situation for which there is no adequate provision in the International Rules of Botanical Nomenclature. It represents a mycologic group possessing distinct pathogenic properties. As a name it is neither misleading nor confusing. We grant that *Fonsecaea* may not be a permanent generic name for the species *Pedrosoi*, but *Hormodendrum* and *Phialophora*, which are also imperfect genera, are not permanent either. Indeed, *Hormodendrum* is worse than *Fonsecaea* in this respect because, according to many well-known authorities, it should be replaced by *Cladosporium*. The correct botanical classification of *Pedrosoi* will be definitely established only when its perfect form becomes known, but there is no way of estimating how long a period will elapse before the sexual phase of this parasite is discovered, if discovered at all. In the meantime, it would seem unscientific and inconsistent with one of the fundamental principles of nomenclature to preserve a name which experience has proved to be a permanent source of error, ambiguity and confusion. With the new and broader conception of the species *Pedrosoi* including its different varieties, and with a generic name that is not confusing nor misleading, the classification of any fungus isolated in the future from cases of chromoblastomycosis should be a very simple problem.

*Treatment.* Chromoblastomycosis has been subjected to various methods of treatment with varying degrees of success. Up to the present time, no specific drug has been discovered against this dreadful malady. In incipient cases, however, the infection has often been successfully eradicated by surgical or electrotherapeutic methods. When the pathologic process is advanced, amputation of the affected extremity is the only hope for recovery. The iodides, copper used in different forms, and a few other drugs

have been more or less helpful in the hands of different investigators. Local treatment should be conducted along general principles.

#### ADDENDUM

The following Latin diagnosis is given in compliance with the International Rules of Botanical Nomenclature:

FONSECAEA PEDROSOI (Brumpt) Negróni, 1936, emend, variety  
PHIALOPHORICA.

Syn.: *Phialophora macrospora* Moore & Almeida. Ann. Missouri Bot. Gard. 23: 543-552. 1936.

*Phialophora verrucosa*, A. Pedroso & J. M. Gomes. Bull. Soc. Med. Cir. São Paulo 3: 254. 1920; Gomes, *ibid.* 3: 42, 43. 1920; Ann. Paulistas Med. Cir. 11: 53-61. 1920.

*Acrotheca Pedrosoi* Terra, Torres, da Fonseca & Arca de Leao. Brasil Medico 2: 363-368. 1922.

Morphologia essentialiter similis *Fonsecaea Pedrosoi typicus*, sed *Phialophora* sporulatio frequentissima, *Acrotheca* sporulatio rara et *Hormodendrum* sporulatio obsoletus.

SCHOOL OF TROPICAL MEDICINE,  
SAN JUAN, P. R.

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# POLYCHYTRIUM: A NEW CLADOCHYTRIACEOUS GENUS

LIBERO AJELLO<sup>1</sup>

(WITH 16 FIGURES)

This fungus was collected in decaying vegetable debris from a bog on the ridges of Bearfort Mountain, New Jersey, west of Greenwood Lake, and cultured in bleached sections of young corn leaves in the laboratories at Columbia University. It is characterized by a coarse rhizomycelium, polymorphic sporangia, and hyaline zoöspores with a well developed lunate opaque body and no prominent refractive globule. Inasmuch as it differs in several respects from any of the known genera and species of the Cladochytriaceae a new genus is hereby created for this chytrid. Because of its polycentric type of growth and aggregated sporangia the following names are proposed:

## **Polychytrium** gen. nov.

Rhizomycelium intra- and extramatrical, extensive, coarse, branched, occasionally septate with rhizoids, conspicuous spindle organs or swellings lacking. Zoösporangia non-operculate, terminal and intercalary, variously shaped, spherical, clavate or pyriform. Zoöspores posteriorly uniflagellate, emerging fully formed in a globular mass and remaining quiescent for a few moments before swimming away.

Rhizomycelio intra- et extramatricali, extenso, crasso ramosque, interdum septato cum rhizoideis, neque tumores neque conspicua corpora fusiformia praestante. Zoosporangiis terminalibus et intercalaribus, variatim formatis, sphaericis, clavatis aut pyriformibus, neque operculatis. Zoosporis a posteriore uniflagellatis, maturis in globuloso cumulo emergentibus, aliquamdiu quiescentibus, postea enatantibus.

## **Polychytrium aggregatum** sp. nov.

Rhizomycelium extensive, coarse, tenuous portion, apart from rhizoids, 2-12  $\mu$  in diameter, profusely branched, occasionally sep-

<sup>1</sup> The writer wishes to express his sincere appreciation to Professor J. S. Karling for helpful advice and criticism during the course of this study.

tate, hyaline at first, becoming yellowish-brown at maturity. Zoö-sporangia in aggregates of two or more, terminal and intercalary, non-apophysate, hyaline at first, becoming yellowish-brown at maturity, wall  $.7\ \mu$  thick; smooth to tuberculate; spherical,  $14 \times 29\ \mu$ ; ovoid, ellipsoid,  $12-20 \times 22-40\ \mu$ ; clavate, obclavate,  $12-24 \times 29-102\ \mu$ ; pyriform, obpyriform, elongate, cylindrical,  $8-25 \times 17-75\ \mu$ ; tubercles on sporangia up to  $7\ \mu$  wide at the base and  $5.5\ \mu$  in height; exit pore or tube varying in length, diameter  $3.5\ \mu$ ; proliferating, exit tube of secondary or tertiary sporangia often penetrating the primary sporangial wall. Zoöspores delimited within the sporangium, emerging and forming a motionless, spherical mass at the mouth of the exit pore; spherical  $4.4-5.5\ \mu$  with a conspicuous, large, lunate opaque region,  $1.5-2 \times 3-3.5\ \mu$ , surrounded by several opaque granules, no conspicuous single refractive globule present; flagellum  $24-29\ \mu$  long. Resting spores unknown or doubtful.

Fungus saprophyticus; rhizomycelio extenso, crasso, parte tenui (rhixoides exclusis),  $2-12\ \mu$  diametro, maxime ramoso, aliquando septato, hyalino primo, sed maturitate fulvoso. Zoosporangiis duobus aut pluribus aggregatis, terminalibus et intercalaribus, sine apophysate, hyalinis primo, maturitate fulvosis, pariete  $.7\ \mu$  crasso; polymorphis, levibus ad tuberculatis (tuberculo sporangii usque  $7\ \mu$  lato ab infimo,  $5.5\ \mu$  alto), sphaericis,  $14 \times 29\ \mu$ ; ovoideis, ellipsoideis,  $12-20 \times 22-40\ \mu$ ; clavatis, obclavatis,  $12-24 \times 29-102\ \mu$ ; pyriformibus, elongatis, cylindriceis,  $8-25 \times 17-75\ \mu$ , porum exeuntem aut tubulum varia longitudine habentibus; proliferatis, tubulo exeunte secundorum aut tertiorum sporangiorum parietem primum penetrante. Zoosporis intra sporangium delimitatis, emergentibus et immotilem sphaericum cumulum orifice tubuli exeuntis formantibus; sphaericis,  $4.4-5.5\ \mu$ , cum conspicua, permagna, lunata, opaca regione  $1.5-2 \times 3-3.5\ \mu$ , a compluribus opacis granulis circumdatis, neque conspicuo singulo globulo refractivo praeditis; flagello  $24-29\ \mu$  longo. Sporis perdurantibus incompertis aut dubiis.

Saprophytic in decaying vegetation in bogs, Bearfort Mountain, Passaic County, New Jersey.

*Polychytrium* differs from the seven genera that at present comprise the family Cladochytriaceae in several respects. The sporangia of *Polychytrium* dehisce by the deliquescence of the tip of the exit-pore thus being clearly differentiated from the two operculate genera, *Nowakowskiella* and *Septochytrium*. *Amocbochytrium* is unique in having aflagellate zoöspores, *Polychytrium* and the other genera of the family having posteriorly uniflagellate spores. The zoöspores of *Catenaria* usually emerge singly from the zoösporangium and immediately swim away. Those of *Poly-*

*chytrium*, *Cladochytrium*, *Nowakowskiella* and *Septochytrium* emerge and form a more or less globular mass at the mouth of the exit tube. After a short quiescent period the mass breaks up and the spores swim away. The zoöspores of *Physocladia*, on the other hand, according to Sparrow (1931) behave quite differently from those of all the other genera in that they are confined in a thin but rigid, hyaline vesicle upon emerging from the sporangium. The rhizomycelium of *Polychytrium* is coarse and myceloid in character with no spindle organs or intercalary swellings. Rhizoids are not as numerous nor as extensively developed as those of various species of *Cladochytrium*. They are frequently difficult to distinguish, and offhand the rhizomycelium looks strikingly like the mycelium of members of the *Oömycetes* or *Zygomycetes*. In comparison to *Polychytrium* the absorbing system of the other genera of the Cladochytriaceae varies from the thick, almost cylindrical rhizomycelium as in *Catenaria*, which also lacks well-defined spindle organs to the extensively branched thallus of *Cladochytrium* in which intercalary swellings are numerous and well developed. *Physoderma* is markedly different from *Polychytrium*, for it has septate turbinate organs and its evanescent thin-walled sporangia arise on monocentric thalli.

#### DEVELOPMENT OF THE THALLUS

The living zoöspores of *P. aggregatum* are distinguished from most of the members of the family Cladochytriaceae by the lack of a conspicuous refringent globule and the presence of an opaque lunate body, 3–3.3  $\mu$  in diameter, which is usually bordered by several minute granules (FIG. 2). In only one other species of this family has such an opaque body been reported in living zoöspores. The zoöspores of *Catenaria sphaerocarpum* were described by Karling (1938) as containing a crescentic, opaque body, but its zoöspores also include a large refractive globule. Fixed and stained zoöspores of other chytrids and Phycomycetes have revealed crescentic bodies similar in appearance to the lunate structure observed in the living zoöspores of *P. aggregatum*. Karling (1937) found that the fixed zoöspores of *Cladochytrium replicatum* contained an extra-nuclear cap, and Hillegas's (1940) cytological investigation of *Endochytrium operculatum* also revealed such a

body in the zoöspores. Extra-nuclear caps have also been described in the zoöspores of *Coelomycidium Simulii*, *Rhizophidium beauchampi* and *Clavochytridium stomaphilum* by Debaisieux (1920), Hovasse (1936) and Cox (1939) respectively. Extra-nuclear caps are more prevalent and well developed in the Blasocladales. In various species of *Blastocladia* and *Allomyces* Thaxter (1896), Barrett (1912), Kniep (1929), Cotner (1930) and Hatch (1935) found well developed and striking extra-nuclear caps. These structures are doubtless more widely distributed among the lower fungi than is generally supposed and their presence may or may not be specific and fundamentally significant in phylogeny. Aside then for the presence of an opaque, lunate body visible in the living zoöspores and the lack of a conspicuous refractive globule, the zoöspores of *P. aggregatum* resemble in form and activity those of other species in the family Cladochytriaceae. The zoöspore is medium in size ( $4.4\text{--}5.5\ \mu$ ) (FIG. 2) and spherical in shape upon emergence from the sporangium. Since the diameter of the exit tube or pore is only approximately  $3.5\ \mu$  the zoöspores become elongate while emerging (FIGS. 1f and 3). The zoöspores swim with the aid of a single, posteriorly attached flagellum  $24\text{--}29\ \mu$  in length. Occasionally a globule of cytoplasm or a loop was observed at the tip of a zoöspore's flagellum (FIG. 4). Such zoöspores have been reported for *Synchytrium* by Curtis (1921), for *Macrochytrium* by Minden (1923) and by Berdan (1941) for *Cladochytrium*. These workers attributed this phenomenon to disintegration. Hillegas (1940) in studying *Endochytrium* believed it to probably be a developmental stage. After a motile period of varying length the zoöspores settle down and germinate.

Few stages of germination were observed, but in figure 5 a germinating zoöspore is shown from which a coarse, branched germ tube has developed. This tube grows in length and width and eventually forms the rhizomycelium. The thallus is hyaline when young but soon turns a yellowish-brown in color. It is coarse and profusely branched, with feebly branching rhizoids arising at various points (FIGS. 1d and 6). Except for the presence of rhizoids the tenuous portion of the rhizomycelium, in which septa are occasionally formed (FIG. 1j), has the appearance of a coarse mycelium as in the higher, strictly mycelial fungi. Sporangia in various

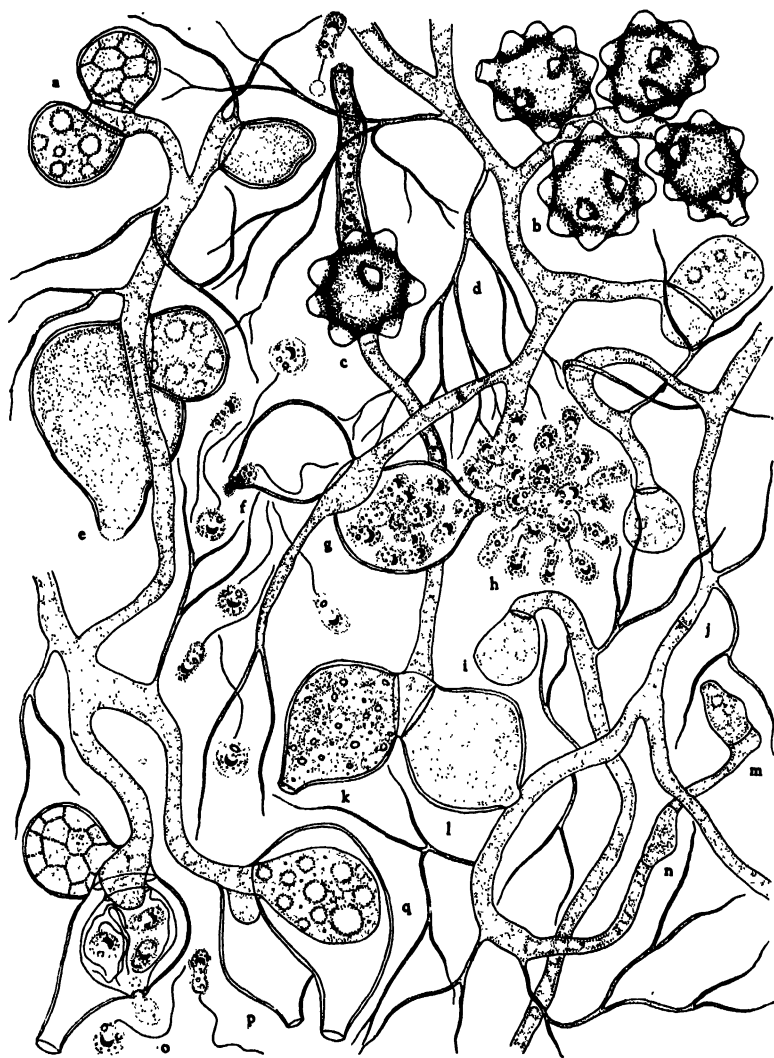
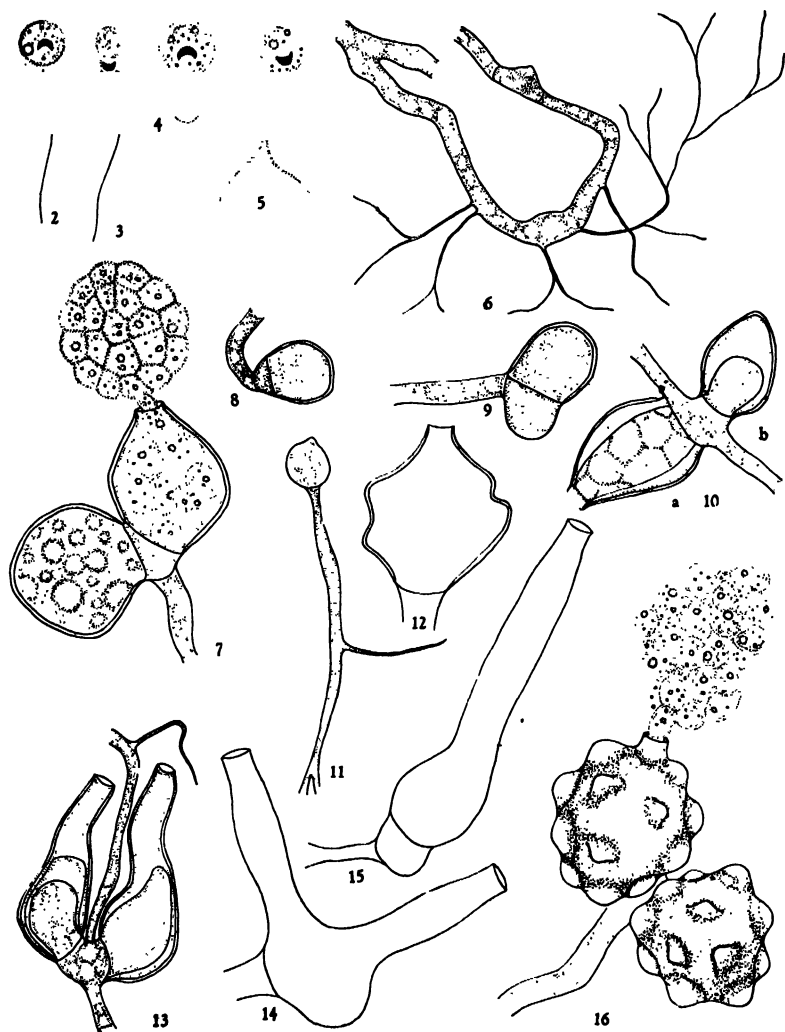


FIG. 1 a-q, habit sketch of the rhizomycelium of *Polychytrium aggregatum*. a, two ovoid zoosporangia in different stages of development, the upper sporangium undergoing cleavage; b, group of tuberculate zoosporangia; exit pore of two visible; c, solitary tuberculate sporangium with long exit tube; zoospores just beginning to emerge; d, group of branched rhizoids; e, pyriform sporangium with homogeneous cytoplasm; companion sporangium much smaller; f, zoospore being constricted while trying to emerge from the zoosporangium; g, sporangium discharging zoospores; h, zoospore mass breaking up; opaque lunate body and flagella visible; i, early stage in sporangial development; septa have cut off the sporangium from the thallus;

stages of development are shown in parts *i*, *m* and *n* of figure 1, which is a habit sketch of the rhizomycelium and also in figures 8, 9 and 11. With age the cytoplasm of the thallus tends to become vacuolate. Zoösporangia appear at various points at the apex and in intercalary positions (FIGS. 1*a* and *b*), and are delimited from the rhizomycelium by septa (FIG. 1*k* and *l*). As the specific name of the chytrid indicates, the zoösporangia rarely occur singly (FIG. 1*c*). In the incipient stages they often seem to arise singly, since one of the pair may develop at a faster rate than its companion (FIG. 1*n*), but in time the two sporangia become approximately equal in size (FIGS. 1*i*, *k*, *l*, *m*, 8 and 9). These sporangia undergo cleavage and form zoöspores either at the same time (FIG. 1*f* and *g*) or separately (FIG. 7). The tuberculate sporangia begin as swellings in the rhizomycelium, which increase in size and develop in the same manner as the smooth sporangia. As noted before, no conspicuous oil-like refractive globules are present in the developing zoösporangia as in the incipient sporangia of most chytrids. Before the zoöspores are delimited by cleavage the cytoplasm becomes homogeneous in appearance and contains scattered opaque granules (FIG. 1*c*). After cleavage the apical portion of the exit pore deliquesces and the zoöspores begin to emerge in the same manner as in *Cladochytrium*, *Nowakowskiella*, etc. (FIG. 1*k*). The first to emerge are surrounded by a viscous fluid-like substance which holds the zoöspores together at the mouth of the exit pore (FIG. 16). Such a slimy matrix appears to be common of all chytrid species of which the zoöspores remain clustered for a short time at the mouth of the exit pore. In *Polychytrium aggregatum* this zoöspore mass rounds up (FIG. 7) and remains motionless as more zoöspores slip into it. In a few moments the individuals making up the mass begin to move and glide over one another. It is at this time that the flagella can first be seen clearly,

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companion sporangium not as yet developed; *j*, septum in the rhizomycelium; *k*, zoöspores about to emerge from the sporangium; lunate opaque body and flagella not as yet visible; *l*, companion to sporangium *k* in an early stage of differentiation; *m*, young sporangium with accompanying sporangium just beginning to develop; *n*, incipient intercalary sporangium; *o*, 'secondary' sporangium whose exit pore has broken through the primary sporangial wall; a 'tertiary' sporangium is beginning to form within the 'secondary' one; *p* and *q*, stages in sporangial proliferation.



FIGS. 2-16. 2, zoospore showing opaque lunate body surrounded by granules; 3, zoospore elongated while emerging from sporangium; 4, zoospore with a loop at the tip of the flagellum; 5, germinating zoospore; 6, portion of the rhizomycelium showing an incipient intercalary zoosporangium and rhizoids; 7, pair of apical sporangia in different stages of development; 8, young zoosporangium; companion sporangium just beginning to develop beneath; 9, later stage in the development of companion sporangium; 10, proliferating zoosporangium; *a*, cleavage of 'secondary' zoosporangium; *b*, young 'secondary' sporangium; 11, early stage in development of an apical sporangium; 12, median optical view of a tuberculate zoosporangium showing the thickness of its wall; 13, pair of proliferating intercalary zoosporangia

and by the lashing about of the flagella the zoöspores emerge from the mass and swim away (FIG. 1*h*). The zoöspores which emerge from the sporangium after the mass breaks up have a clearly visible flagellum (FIG. 1*o*). The opaque lunate body of these zoöspores is also quite evident at this time in contrast to its faint appearance in the initial zoöspores which compose the mass at the mouth of the exit tube. In the latter zoöspores the lunate body becomes more visibly prominent at the time of the break up of the zoöspore mass (FIG. 1*h*).

The shape of the sporangia varies widely in *P. aggregatum*, and ranges usually from spherical, ovoid, to pyriform (FIG. 1*a* and *e*). Long cylindrical sporangia also occur (FIG. 15). Beside these variations in sporangial form, tuberculate sporangia may also be present on the same thallus with the smooth ones. These sporangia usually have 8 to 11 well developed tubercles upon their surface (FIGS. 1*b* and 16) which measure up to  $7\ \mu$  at the base and  $5.5\ \mu$  in height. In the incipient stages, the tuberculate sporangia are indistinguishable from the smooth ones and arise in the same manner either in an intercalary or apical position. As they develop further, however, the tubercles begin to form and at maturity they too become yellowish-brown in color. Whether or not these tuberculate sporangia should be considered as resting spores is not certain at present because their sporangial wall is not appreciably thicker than that of the smooth sporangia (FIG. 12). They are nevertheless, very similar in appearance to the resting spores of most cladochytriaceous species. Their exit tubes may be well developed (FIG. 1*c*) or commonly papillate, solitary (FIG. 1*k*) or in twos (FIG. 14).

Sporangial proliferation is quite common in this chytrid, with the secondary and tertiary sporangia being formed within the empty shell of the primary one (FIG. 13). Early stages in the formation of "secondary" sporangia are shown in figure 1*p* and *q*. The proliferating sporangia are formed by the ingrowth of the protoplasm from the rhizomycelium beneath as in most polycentric chytrids. The incipient "secondary" sporangium is at first hyaline

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with 'secondary' and 'tertiary' sporangia; 14, zoosporangium with two exit tubes; 15, cylindrical sporangium; 16, pair of tuberculate sporangia; upper one discharging zoospores.



and homogeneous (FIG. 10*b*) and undergoes the same stages of enlargement and differentiation as the primary sporangia (FIGS. 10*a* and 13). The exit papillum of the proliferating sporangium may be formed within the primary sporangium (FIG. 10*a*) or may push through the wall of the enclosing sporangium (FIG. 10).

#### SUMMARY

*Polychytrium aggregatum* is a new, polycentric, saprophytic species of the family Cladochytriaceae which occurs in the decaying vegetation of bogs in the ridges of Bearfort Mountain, Passaic County, New Jersey. It has a coarse, richly branched rhizomycelium which becomes yellowish-brown at maturity, and lacks spindle organs or intercalary enlargements. The sporangia are smooth or tuberculate and produce spherical, posteriorly uniflagellate zoöspores which lack a conspicuous refractive globule but include a prominent opaque lunate body. The sporangia dehisce by the deliquescence of the tip of the exit tube or papilla. Dormant thick-walled resting spores have not been observed, but the irregular tuberculate yellowish-brown sporangia are strikingly similar to the resting spores of many Cladochytriaceous species. However, they produce zoöspores directly without going through a dormant period.

DEPARTMENT OF BOTANY,  
COLUMBIA UNIVERSITY,  
NEW YORK, N. Y.

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# COCCIDIOIDOMYCOSIS<sup>1</sup>

C. W. EMMONS

(WITH 18 FIGURES)

Coccidioidomycosis was first studied and reported by Posadas (30) and Wernicke (38) in South America. Observing a resemblance of the fungus seen in tissue sections to certain *Coccidia* they described the condition as a new protozoan disease. In 1894 Rixford independently found the disease in California. Rixford and Gilchrist (32) later reported this case, described it as coccidioidal pseudotuberculosis, and named the organism *Coccidioides immitis*. In 1900 Ophuls and Moffitt (29), studying the third North American case, proved by culture that the etiological agent was a fungus. The original misconception of the nature of the microorganism does not invalidate the name and the fungus is properly referred to as *C. immitis* Rixford & Gilchrist 1896.

The disease occurs in two forms (13, 14, 22, 23, 35). One is a benign, acute, self-limited, respiratory infection; the second is a grave, chronic, generalized, progressive, granulomatous disease with a mortality rate of about 50 per cent. Both have been known for many years in the San Joaquin Valley of California and were believed to be two unrelated diseases until Gifford (22, 23) and Dickson (13, 14, 15) demonstrated that *C. immitis* is associated with both conditions. Dickson (13) at that time proposed the names primary and secondary or progressive coccidioidomycosis by which the two types of the disease are now generally known.

The first of these, primary coccidioidomycosis, varies widely in severity. It probably occurs in many individuals in a form so mild as to be unrecognized. The severity of recognized cases may correspond to that of a common cold. More severe cases may resemble influenza and may be accompanied by high fever, pneumonia, and formation of pulmonary cavities. In perhaps 5 per cent of those infected erythema nodosum may be expected and

<sup>1</sup> Division of Infectious Diseases, National Institute of Health.

the disease is then recognized clinically as Valley fever, San Joaquin fever, desert rheumatism, "the bumps," etc. Irrespective of the severity of the primary disease, spontaneous recovery usually follows. Epidemiological studies (34) seem to indicate that it progresses to the secondary type only in exceptional cases. Reinfection appears to be infrequent.

Progressive or secondary coccidioidomycosis (6, 7, 32, 33) (coccidioidal granuloma) is manifested by cutaneous, subcutaneous, visceral, and osseous lesions. It often resembles tuberculosis so closely that a differential diagnosis can be made only by the laboratory demonstration of the fungus. It was once believed to be invariably fatal but milder and arrested or healed cases are now recognized. It is not definitely known whether progressive coccidioidomycosis results from a reinfection or whether it is a reactivation of a latent or temporarily arrested lesion of the primary disease. The fungus has been recovered in culture from arrested and partially calcified lesions in individuals dying of other causes (5, 8, 15). Coccidioidomycosis occurs also in cattle, sheep, dogs, and rodents (10, 11, 4, 20, 24, 18).

The disease is of frequent occurrence in the San Joaquin Valley and probably over large areas of the arid Southwest. It is rarely seen or is unknown elsewhere. Strangely enough, it appears to be rare in South America where it was first seen. Most of the reported cases from this area were paracoccidioidal granuloma (12, 25), a disease differing in clinical characteristics and etiology. Coccidioidal granuloma is a reportable disease in California, and by June, 1939, 578 cases and 278 deaths had been reported (21). It is more difficult to determine how frequently primary coccidioidomycosis occurs. Individuals with the respiratory type of infection do not always raise sputum and an attempt to demonstrate the presence of the fungus may fail even in severe cases which are clinically typical of coccidioidomycosis. In an "epidemic" of seven cases probably infected from a common exposure, the fungus was demonstrated in only three of the seven (31). In Smith's (34) epidemiological study of 432 cases of Valley fever occurring in the San Joaquin Valley during a period of 17 months, *Coccidioides* was recovered from only 22 per cent of the patients. Smith estimated that only about 5 per cent of those who have had



FIGS. 1-6. *Coccidioides immitis*.

the infection presented clinical symptoms sufficiently severe and well defined to allow a clinical diagnosis to be made. This estimate was based on information obtained by the use of a skin test similar to the tuberculin test.

The testing material, coccidioidin (19), is prepared by allowing strains of the fungus to grow for two months in a synthetic broth. The broth is then filtered and the sterile filtrate is diluted and 0.1 cc. is injected intradermally. An area of erythema and edema

appears around the site of injection in sensitized individuals. The reaction is read in 24 and 48 hours after injection. It gradually disappears. The assumption that the test is specific and that a positive reaction indicates a previous infection with the fungus is supported by several lines of evidence (36, 34). Skin sensitivity suddenly develops in man a few days or a few weeks after attacks of primary coccidioidomycosis. A recent infection usually gives rise to a more severe reaction than an infection incurred several years previously. Individuals with secondary coccidioidomycosis react less strongly than those with the primary type, and in the terminal stages may fail to react. A cross reaction with tuberculosis and other diseases has not been clearly demonstrated. Experimentally infected guinea pigs acquire a sensitivity to the intradermal injection of coccidioidin. The coincidence of a high percentage of positive reactions in the residents of an endemic area and their rarity or absence elsewhere is also noteworthy. There is not complete agreement on the correct interpretation of the coccidioidin skin test (36), and the preparation of coccidioidin of reproducible potency still presents difficulties, but the test is the best available method of determining the prevalence of past *Coccidioides* infections.

Some of the recent data on the prevalence of skin sensitivity to coccidioidin in residents of endemic areas and its rarity or absence in other populations have been brought together by Farness (21). From 16 per cent to 90 per cent of the individuals in certain groups within endemic areas react. The highest percentage of reactors was reported by Aronson, et al. (1, 2), who found that a very high percentage of the Indian school children on the San Carlos, Pima, and Papago Indian reservations in southern Arizona reacted to coccidioidin. In spite of the prevalence of positive skin reactions neither primary nor progressive coccidioidomycosis is commonly seen in these groups. Suspected cases were seen on the reservations, and histories of earlier suspected cases were obtained, but none of these were proved. It seems probable that the disease is prevalent in these areas and that most of the adult residents have at some time been infected, in most cases during early childhood. It is not yet apparent why the disease is not often seen and recognized on these Indian reservations. It is probable that

FIGS. 7-12. *Coccidioides immitis*.

in the comparatively stable populations of these areas it is an unrecognized mild disease of early childhood. In the San Joaquin Valley it is seen as a more severe disease among migrant or newly resident adults or children of school age (22, 34).

So far as we know, coccidioidomycosis is not transmitted directly from man to man (34). The parasitic phase of the fungus

which occurs in human pus and sputum is infectious when experimentally injected into animals, but apparently is not effective in the natural direct transmission of the disease. Spores from the saprophytic growth phase of the fungus are also infectious. Epidemiological studies (16, 34, 35), accidental laboratory infections (14, 17, 34), and experimental infection of guinea pigs by inhalation (9) make it seem probable that man is ordinarily infected by inhalation of air-borne spores of the fungus. There is a remarkable association of cases of the disease and previous exposure to dust storms or occupational exposure to agricultural dust (17). It is generally assumed that the spores of the saprophytic growth phase of the fungus are present in such dust and that the fungus was growing in the soil from which the dust arose. Additional evidence for both assumptions is desirable. In spite of many attempts to isolate *Coccidioides* from soil, success has been reported only three times. The first isolation was from soil taken near the sleeping quarters of a Delano ranch where there were four cases of progressive coccidioidomycosis (37). Contamination of this soil by pus and sputum from the patients may have accounted for the success in this isolation. The second instance (35) was in San Benito County, California, and the details of this isolation have not yet been published. Both these sites were within the known endemic area of Southern California.

Recently five isolations of *Coccidioides immitis* were made from desert soil collected at distances up to four miles from human habitations in the vicinity of San Carlos, Arizona (18). The fungus was also isolated for the first time from rodents (18). These isolations are further noteworthy because they demonstrated the presence of the fungus in that area before the occurrence of the disease was conclusively demonstrated. No clinical case of coccidioidomycosis in man has yet been proved on the San Carlos Indian Reservation, although the disease undoubtedly occurs there.

*Coccidioides* appears in animal tissues (15, 28, 29, 32, 39) only as spherical cells which vary in diameter from spores of one or two microns to mature sporangia 30–60  $\mu$  in diameter. This parasitic growth phase may develop *in vitro* under certain conditions (27, 3). On ordinary artificial culture media, it is a Hyphomycete reproducing by conidia or oidia (29, 15). Each of these forms



will be considered in some detail with descriptions of certain cytological and morphological details not hitherto described.

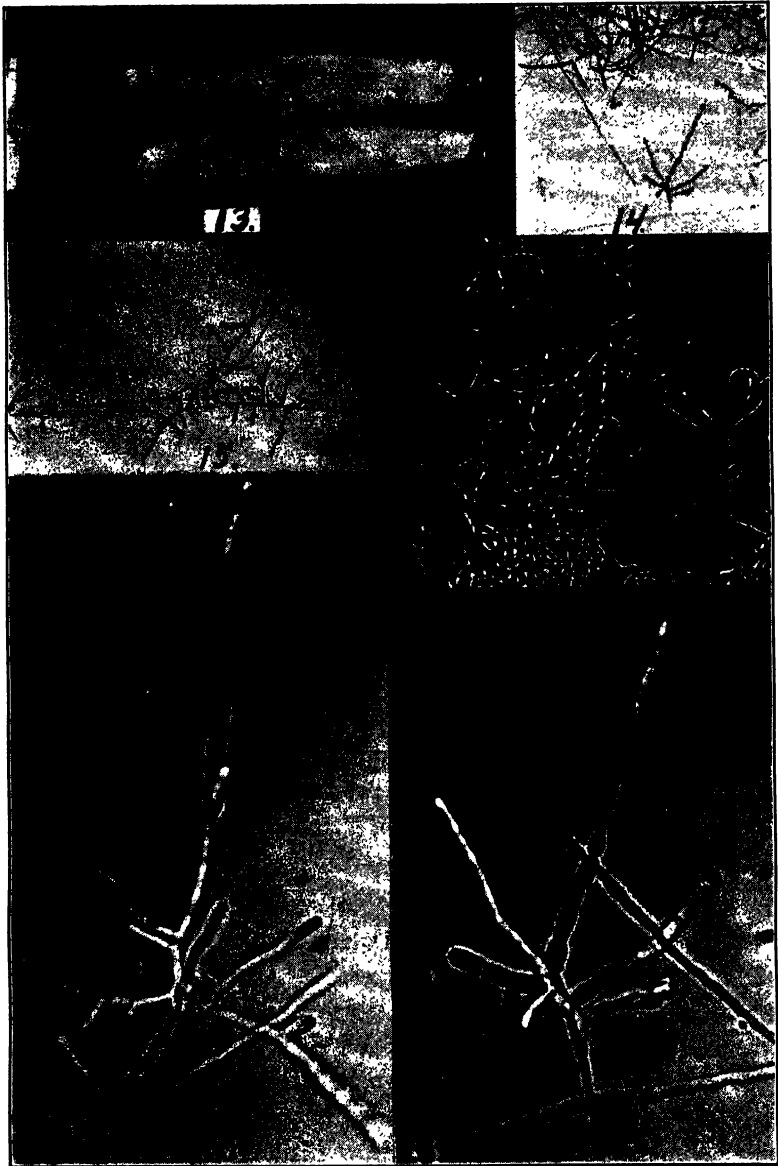
The newly disseminated spores in animal tissue or pus are often difficult to demonstrate. They may be intracellular (FIG. 1) or intercellular. As they increase in size, they retain the spherical shape (FIGS. 1-6). Budding never occurs. A central vacuole is apparent in the early stages of enlargement (FIG. 2). In older individuals this central vacuole occupies most of the cell, the stainable cytoplasm being distributed in a thin peripheral layer (FIG. 6). As the cell assumes the functions of a sporangium the amount of peripheral stainable cytoplasm increases and becomes vacuolate (FIG. 7). The small vacuoles in this peripheral layer probably determine the location of cleavage planes which now form radially (FIG. 8). Cell walls are laid down along these cleavage planes and delimit an indefinite number of large protospores (FIGS. 9, 10). The progressive formation of additional septa in both radial and tangential planes subdivides the protospores into spores with a diameter in most cases of 1-3  $\mu$  (FIG. 11). This process resembles the method of sporangiospore formation which Harper (24a) described for the *Phycomycetes*. The mature sporangium is filled with these spores. Its wall then breaks, allowing them to pass into the surrounding host tissues (FIG. 12). This simple cycle is repeated and constitutes the sole parasitic growth phase of the fungus. The general features of this developmental cycle have been well illustrated in numerous papers. Numerous variations such as the occasional formation of larger spores in certain fungus strains or in certain host tissues, and the precocious development of spores while still within the sporangium have also been described.

Apparently no attention has been given to the nuclear condition, probably because the nuclei are not readily demonstrated in the usual histological preparations. The preparations illustrated herewith were fixed with a modification of Bouin's fixative and stained with Haidenhain's iron alum hematoxylin. The spores probably contain a single nucleus in most instances (FIG. 12), but a multinucleate condition is early established in the developing cell (FIGS. 2, 3). These nuclei are typical of fungus nuclei, having a thin nuclear membrane and a single nucleolus. As the cell increases

in size, an increasing number of nuclei appear in the peripheral layer of cytoplasm (FIG. 6). These are not separated by cell walls, but are scattered, the spatial relationships being more apparent in slab sections of cells than in the median sections illustrated. After the process of spore delilimation is initiated, the protoplasm is divided by the newly formed walls into multinucleate protospores in the manner previously described (FIG. 10). The spores which result from the further subdivision of the protoplasm appear to be uninucleate in most cases (FIG. 12). Mitotic figures were not found in these preparations.

The saprophytic growth phase on artificial culture media is that of a mold. Growth is rapid. The colony may be glabrous at first, but aerial hyphae are usually formed in abundance (FIG. 13), at least in the center and in a peripheral zone. The general aspect is that of a rather coarse growth but actually most of the hyphae are unusually delicate. The color of the colony is gray or brownish white.

It is commonly stated that the aerial hyphae break up into chlamydospores. This is the impression one gains from the examination of an old culture (FIG. 16). Long chains of spores or fragments of chains are conspicuous but the details of spore production cannot be observed in such preparations. If a five day old culture is carefully examined, it is apparent that the spores are not merely the segmented fragments of the aerial vegetative hyphae. They are borne on well differentiated conidiophores (FIGS. 14, 15, 17, 18). These arise as specialized side branches which are almost twice the diameter of the vegetative hyphae and may be simple (FIG. 15) or branched (FIGS. 14, 17, 18). Septa are formed at frequent intervals on the terminal portions of these conidiophores. Alternate cells, after being thus delimited, increase in size and turgidity and in thickness of the wall (FIG. 18). The intervening cells cease development and gradually lose any demonstrable cytoplasm. The walls persist and hold the spores together in chains (FIG. 16). These chains of mature spores separated by dead or empty cells are familiar from numerous published photomicrographs and drawings. They resemble and are usually called chlamydospores. From a consideration of the manner in which they are borne, it is suggested that they should instead be designated conidia or oidia.

FIGS. 13-18. *Coccidioides immitis*.

Spirally coiled hyphae similar to those found in certain strains of dermatophytes are frequently present (FIG. 16). Baker and Mrak (3) have recently described the development in old agar

cultures of sporangia similar to those which characterize the parasitic phase of growth.

#### SUMMARY

Coccidioidomycosis is a mycotic disease which occurs in a benign primary form and as a grave progressive disease. It has a limited geographic distribution. The prevalence of positive coccidioidin skin tests in endemic areas indicates that a high percentage of the residents of such areas have at some time been infected. The disease is most apparent in migrant or newly resident adults. The parasitic growth form of the fungus is infectious but appears to be ineffective in the direct natural transmission of the disease. There is an apparent association between exposure to dust storms or occupational exposure to agricultural dust and subsequent infection. It is generally assumed that spores of the saprophytic growth form are present in such dust. The fungus has been isolated from soil in three areas and from cattle, sheep, dogs, and rodents. The multi-nucleate condition of the fungus, sporangiospore formation in the parasitic growth form, and the development of the conidiophores and conidia of the saprophytic growth form are described.

NATIONAL INST. OF HEALTH,  
WASHINGTON, D. C.

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## EXPLANATION OF FIGURES

*Coccidioides immitis*. Magnification of Figs. 1-12 about 600 X. Fig. 1, Young vegetative cell within a phagocytic cell. The multinucleate condition is already established. Fig. 2, Young vegetative cell showing several nuclei and a large vacuole. Fig. 3, Two young vegetative cells. Fig. 4, Increase in size of cell and in number of nuclei. Fig. 5, Vacuolate condition of peripheral layer of protoplasm. Fig. 6, Vegetative cell has reached mature size. Fig. 7, Increase in amount of protoplasm in young sporangium and appearance of vacuoles which precedes cleavage. Fig. 8, Cleavage planes and beginning of wall formation. Figs. 9 and 10, Formation of multinucleate protospores. Fig. 11, Subdivision of protospores by formation of septa in radial and tangential planes to form sporangiospores. Fig. 12, Rupture of sporangial wall. Fig. 13, Cultures one month old on acid dextrose agar. Fig. 14, Low power view of branched conidiophore. Fig. 15, Low power view of simple and branched conidiophores. Fig. 16, Spirals and chains of conidia from an old culture. Note intervening empty cells. Figs. 17 and 18, Branched conidiophores showing some details of formation of conidia. X about 600.

# REVISIONARY STUDIES IN THE CORYNELIACEAE

HARRY MORTON FITZPATRICK

(WITH 43 FIGURES)

This paper, inclusive of a second part to appear in the next number of MYCOLOGIA, constitutes a revision of the writer's earlier monographic treatment of the Coryneliaceae, published in this journal over twenty years ago.<sup>1</sup> In the intervening period a considerable amount of additional material has been studied, some new and hitherto misplaced species have been incorporated, and changed viewpoints on essential features of morphology have resulted in altered conceptions of generic limits.

The family Coryneliaceae was established by Saccardo<sup>2</sup> to embrace the two genera *Corynelia* Acharius and *Tripospora* Sacc. Later he<sup>3</sup> included also *Coryneliella* Hariot and Karsten. In 1897, in Engler und Prantl's *Die Natürlichen Pflanzenfamilien*, the family, consisting of these three monotypic genera, was placed by Lindau in the Sphaeriales alongside the Cucurbitariaceae. In the writer's taxonomic arrangement of the group the four genera *Corynelia*, *Tripospora*, *Sorica*, and *Caliciopsis* were recognized. The genus *Coryneliella*, known only from the type collection and clearly not a member of the family, was excluded. The paper constituted the first serious effort to provide adequate descriptions and separations of the species, and was based on the study of many more collections of material than had previously been assembled in any herbarium. The dehiscence of the ascocarp in *Corynelia* by definite apical cleavage, which had not been noted by earlier workers, was described and figured for the first time. The absence of a true ostium in all members of the family was emphasized, and relationship with the Perisporiaceae was suggested.

<sup>1</sup> *Mycologia* 12: 206-267. fig. 1-49. 1920.

<sup>2</sup> *Syll. Fung.* 9: 1073. 1891.

<sup>3</sup> *Syll. Fung.* 11: 385. 1895.

In 1912 Arnaud,<sup>4</sup> who regards the fruit-body in *Corynelia* and related fungi as a true apothecium, had placed the known species in the Caliciaceae. Ten years after the publication of our monograph, he<sup>5</sup> presented a revision of his earlier paper, reiterating his belief that the fructification is discomycetous, and recognizing the Coryneliées as a subdivision of the Caliciaceae. His viewpoint arose largely from placing undue emphasis on the superficial resemblance of *Caliciopsis* to *Calicium*. In both genera the ascocarp is stipitate, and in both the ascospores extrude at its apex forming a pulverulent plug or knob. The fruit-body in the Coryneliaceae is, nevertheless, certainly not an apothecium. Though it opens widely at maturity, the arrangement of the asci is typically pyrenomycetous. They do not form a palisade-like hymenium. Instead they are fasciculate, and stand at various heights on extremely slender, long stalks. Avoidance of the term apothecium in our earlier paper led naturally, at that time, to the use of perithecium. It is now clear, however, in the light of later research on the ontogeny of the ascocarp in the loculate, stromatic series of higher Ascomycetes, that the fructification in the Coryneliaceae cannot properly be designated a perithecium. There is no perithecial wall, and the ascigerous cavity results from lysigenous action in the tissue of the stromatic lobe above the developing asci. Paraphyses and a true ostiolum are lacking, and the ascocarp is definitely dothideaceous in type. These points were demonstrated conclusively in our laboratory by Helene McCormack<sup>6</sup> in a study of the development of the fruit-body of *Caliciopsis pinea*, and corroborative evidence has been obtained by us in *Corynelia uberata*. It seems best at present to be content with the more general term ascocarp. Its use for the whole lobe containing the ascigerous locule has been adopted for the sake of uniformity in terminology throughout the paper, but is admittedly somewhat open to criticism in that the limits of stroma and ascocarp are only vaguely indicated. This is especially evident in *Caliciopsis pinea* and similar forms in which the locule occupies only a small part of a long, columnar projection of the pulvinate stroma.

<sup>4</sup> Ann. Ecole Nat. Agric. Montpellier, n.s. 12: 24-49. 1912.

<sup>5</sup> Annales des Epiphyties 16: 235-302. 1930.

<sup>6</sup> Mycologia 28: 188. 1936.



The Coryneliaceae approach the Perisporiaceae in the form and nature of the ascocarp, and, except in *Corynelia*, in the type of its dehiscence. They differ in that the mycelium is endophytic instead of superficial, and in that the stroma is erumpent. Dehiscence in *Corynelia* is by apical cleavage, the tip of the ascocarp opening widely, usually along a single transverse suture. Though this recalls the situation in the Hysteriales, that group, on account of difference in form and arrangement of the asci, can scarcely be regarded as close. Though the interrelationships of the various groups of loculate Ascomycetes remain somewhat obscure, there is ample justification for retention of the family Coryneliaceae among them.

Inclusion, within the limits of the single family, of genera characterized by two wholly different types of dehiscence emphasizes our conviction that the species embraced are nonetheless closely related. Indeed, in our earlier paper the genus *Corynelia* included species representative of both types of dehiscence. Though we now remove from that genus the species in which dehiscence is by apical perforation, it is scarcely possible to transfer them to a separate family. In one of them, *C. fructicola*, the ascospores resemble the highly specialized spores of *Corynelia* far too closely\* to leave doubt as to the nearness of the relationship. Also, the fact that the species of three of the five genera incorporated in the family occur only on *Podocarpus* is regarded as significant.

The accessory fruit-bodies, occurring in various species and regarded by us earlier as pycnidia, are here termed spermogonia. This change is based largely on results obtained by Ray<sup>7</sup> in *Caliciopsis pinea*. Following artificial spermatization, he obtained ascocarps in pure culture on agar. Though similar work on other species has not been undertaken, the pycnidium-like body is probably uniform in character throughout the group.

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CORYNELIACEAE Sacc. Syll. Fung. 9: 1073. 1891.

*Coryneliaceae* Sacc. in Berlese & Voglino, Addit. Syll. Fung. 193. 1886.

<sup>7</sup> *Mycologia* 28: 207. 1936.

*Coryneliales* Seaver & Chardon, Sci. Surv. Porto Rico & Virgin Islands, N. Y. Acad. Sci. 31: 40. 1926.

Mycelium endophytic, in most cases parasitic; stromata formed within the host, early erumpent as coriaceous to carbonaceous, sharply demarcated, small, black cushions; surface of stroma soon putting out hemispherical to conical lobes which undergo further, vertical elongation and mature into spermogonia or ascocarps; spermogonia usually preceding the ascocarps, in some species lying among them, in others developed on separate stromata; mature spermogonium sessile to short-stipitate, with a minute, apical perforation; spermatia unicellular, elongate, hyaline to yellowish; ascigerous lobes undergoing considerably greater elongation than the spermogonial, in some species lengthening into slender, cylindrical columns; the entire lobe, regardless of its extent or form, termed here the ascocarp; ascocarp dothideaceous in type, lacking a true perithecial wall, and forming an ascigerous locule by lysigenous action in the stromatic tissue above the developing asci; location of the locule in the ascocarp varying in different species from basal to apical; apex of ascocarp rounded and undifferentiated, or definitely and variously lobed, never possessing a true ostiolum, in dehiscence opening widely by a single transverse cleft or several radiating ones, or perforated and dilated to funnel-form by the pressure of extruding ascospores; asci (p. sp.) ovate to clavate, with thin, evanescent walls and extremely long, delicate stalks, chiefly 8-spored; paraphyses and paraphysoids lacking; ascospores crowded, inordinate, unicellular, various in shape, smooth or echinulate, brown to hyaline, when very young polygonal from mutual pressure and with characteristically refractive centers.

#### KEY TO GENERA OF CORYNELIACEAE

- A. Ascocarp apically dehiscent by a single, deep transverse cleft or several radiating ones; ascospores large, spherical, echinulate, thick-walled, and provided with prominent germ-pores .....1. *Corynelia*
- B. Dehiscence not by cleft; ascocarp at maturity apically perforated and dilated to funnel-form by the extruding ascospores; the spores filling the funnel to overflowing, and giving it the aspect of a pulverulent, subglobose knob or convex disc; finally, following spore dissemination, the inner surface of the funnel exposed to view.
  1. Four stout, radiating lobes giving the ascospore the form of a caltrop .....2. *Tripuspora*
  2. Ascospores spherical to ellipsoidal or subfusiform.
    - a. Ascospores closely resembling those of *Corynelia*, but less uniformly spherical and exhibiting greater variation in size.
      3. *Coryneliospora*

## b. Ascospores smooth.

- (1) Ascospores large, with extremely thick walls; ascus 2-spored; species occurring only on *Podocarpus* .....4. *Lagenulopsis*
- (2) Ascospores much smaller, with thin walls; ascus 8-spored; species not occurring on *Podocarpus* .....5. *Caliciopsis*

1. *CORYNELIA* Acharius ex Fries, Syst. Myc. 2: 534. 1823.  
(Obs. Myc. 2<sup>2</sup>: 343. 1818.)

TYPE SPECIES, *Corynelia uberata* Fries.

Stromata rounded to slightly elongate, scattered to crowded, sometimes confluent, usually hypophyllous, not uncommonly amphigenous, caulicolous or fructicolous; all species parasitic on *Podocarpus* only; ascocarps usually covering the stroma more or less completely, but sometimes formed only at its margin as a single row of nearly horizontal, radiating individuals bordering a prominent, central cushion, in all cases appearing to be seated on the stroma, but actually with their bases somewhat buried in it, clearly not stipitate; mature ascocarp vertically elongate, composed usually of a rounded subconical to subcylindrical basal portion and a more or less broadly clavate upper part; the two usually tapering upward and downward respectively to provide a somewhat narrowed or constricted middle zone, thus giving the ascocarp a more or less dumb-bell shape; the whole interior of the ascocarp at maturity constituting an ascigerous locule, the lower portion containing the young asci, the upper part filled with more mature asci and free ascospores; the apex of the ascocarp differing in external aspect in the several species, in some definitely and characteristically lobed; dehiscence usually along a single, prominent, transverse, terminal groove, a deep cleft being formed which opens widely as a definite mouth; in some cases similar apical rupture accomplished by splitting along several radiating grooves, the resultant mouth bordered by three or more pointed, recurved lobes; ascus 1-8-spored; ascospores spherical, brown, thick-walled, and echinulate; the wall composed of a thin exospore and a thick endospore, and provided with a number of germ-pores which appear as lighter-colored, circular areas.

In the writer's earlier monograph, nine species were recognized. In two of these, *C. fruticola* and *C. bispora*, dehiscence is by apical perforation rather than by cleavage. These are now removed and made the types of two new genera, *Coryneliospora* and *Lagenulopsis* respectively. The other seven are retained in *Corynelia*. No additional species have meanwhile been added, but the study of

more favorable material has altered our conception of certain features, especially in *C. tropica* and *C. brasiliensis*. Our earlier diagnoses of all the species are here rewritten in abbreviated form in the light of improved knowledge and an altered terminology. As the members of the genus occur in widely separated and often inaccessible regions in lands remote from the mycological centers of the Northern Hemisphere, few students of the fungi have collected them, and few of even the larger herbaria contain more than a meager representation.

## KEY TO SPECIES OF CORYNELIA

- A. Apex of fully formed ascocarp not definitely lobed; dehiscence occurring along a shallow transverse groove, which crosses the apex but does not extend far down the sides; ascus 8-spored.
  - 1. Mature ascocarp definitely dumb-bell-shaped, and often bent or inequilateral; the apical portion finally of characteristically shaggy aspect .....1. *C. uberata*
  - 2. Ascocarp short-turbinate, with a smooth, rounded apex.
    - 2. *C. nipponensis*
  - 3. Ascocarp usually barrel-shaped or short-cylindrical; the sides marked by longitudinal ridges; the apex sometimes laterally compressed to form an indefinite beak .....3. *C. tropica*
- B. Apex of fully formed ascocarp definitely lobed; dehiscence occurring between the lobes along rather deep grooves which extend far down the sides.
  - 1. Asci chiefly 8-spored; fewer-spored asci lacking or rare.
    - a. Apex of ascocarp typically trilobed .....4. *C. oreophila*
    - b. Apex of ascocarp typically bilobed .....5. *C. brasiliensis*
  - 2. Asci chiefly 3-spored; eight-spored asci lacking or rare.
    - a. Apex of ascocarp typically trilobed .....6. *C. jamaicensis*
    - b. Apex of ascocarp typically bilobed .....7. *C. portoricensis*

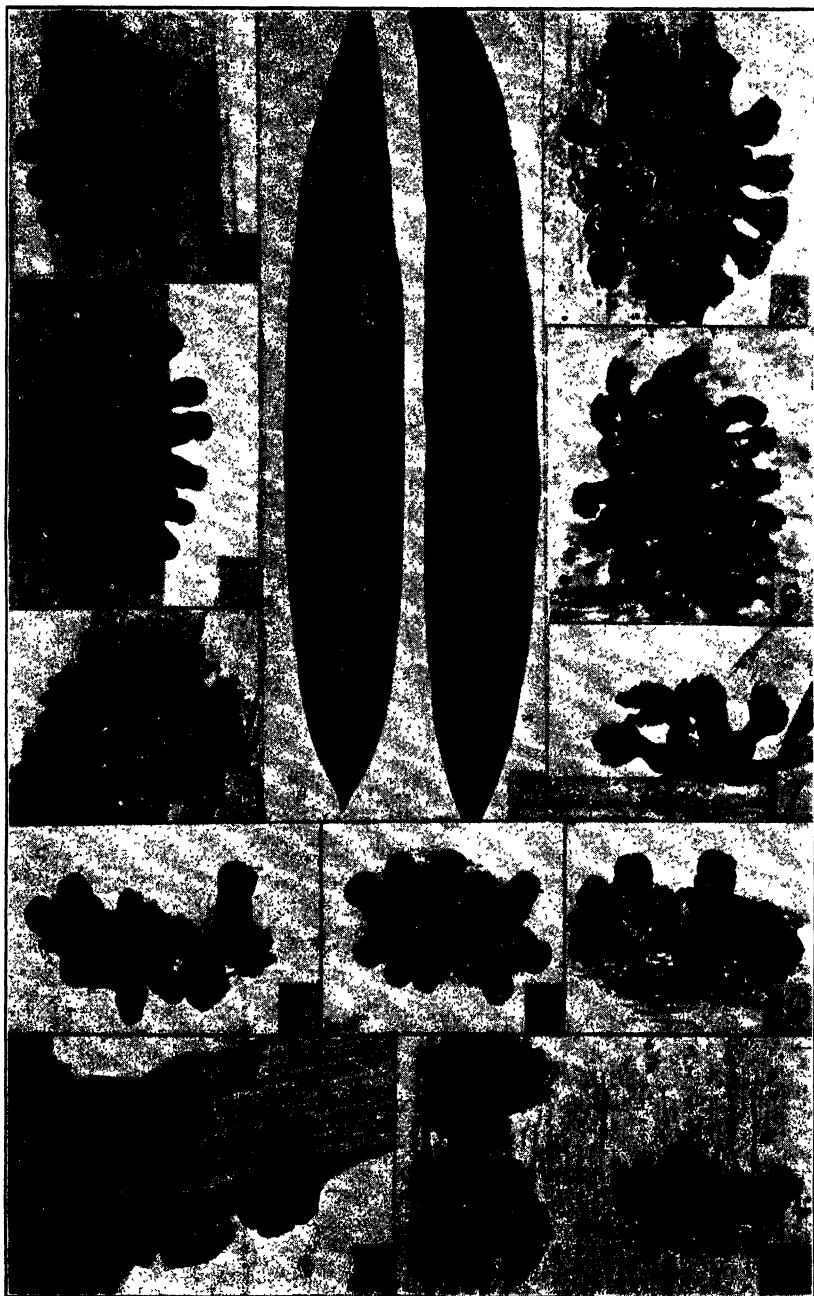
1. *CORYNELIA UBERATA* Fries, Syst. Myc. 2: 535. 1823. (Obs. Myc. 2<sup>2</sup>: 343. 1818.)

*Corynelia clavata* (L.) Sacc., Nuovo Giorn. Bot. Ital. 21: 312. 1889.

TYPE: specimen in herbarium of Fries at Upsala, Sweden, labeled by him "*Corynelia uberata* Fr. Cap. B. sp. Dedit Acharius, Exiguum at characterist."

(FIG. 1-7)

Stroma bearing a crowded, irregularly arranged cluster of ascocarps with occasional, smaller, spermogonia interspersed among



FIGS. 1-12.

them; young ascocarp conical, tapering from a dull, minutely roughened base to a smooth, shiny apex, with elongation becoming apically enlarged to form a broad, clavate beak; mature ascocarp approximately 1 mm. in length, strikingly dumb-bell-shaped, often curved or bent at the narrowed middle zone to give an inequilateral aspect; the swollen, terminal portion finally compressed laterally to form a transverse, apical ridge marked by a line or shallow furrow along which dehiscence occurs; paralleling this line on both sides, the apex commonly cut by one to several secondary furrows; the intervening ridges tending to break up into scales which give a pronouncedly shaggy aspect not present in other species; line of dehiscence merely crossing the apex of the swollen terminal beak, not continued far down its sides; in dehiscence the two lips often spreading far apart, exposing the lighter colored inner surface of the wall; asci (p. sp.)  $34-44 \times 20-26 \mu$ , 8-spored; ascospores  $9-14 \mu$  (mostly 12) in diameter; spermogonium conical to flask-shaped, tapering to a short, prominently perforate beak; spermatia  $5-7 \times 2 \mu$ .

We have studied more collections of this species than of any other, most of them having been made in South Africa, the region from which the species was originally described. We have also seen specimens from equatorial East Africa, Japan, and Australia. A single, fragmentary specimen from the Philippine Islands, cited in our earlier paper, is now regarded as doubtful. Though Cooke<sup>8</sup> records the species from New Zealand and figures ascocarps having

<sup>8</sup> Handbook of Australian Fungi, p. 318, fig. 242. 1892.

FIGS. 1-7. *Corynelia uberata*. 1, a cluster of ascocarps radiating from a stroma on a leaf of *Podocarpus spinulosa* from Australia,  $\times 11$ . 2, another cluster from the same collection, with plane of focus adjusted to show the transverse apical furrows, the central one of which marks the line of dehiscence,  $\times 11$ . 3, another cluster collected at the same place at a later date, showing apical dehiscence by a single transverse cleft,  $\times 11$ . 4, a cluster from the same collection, showing the occasional extreme enlargement of the apical portions; spermogonia also present,  $\times 11$ . 5, two leaves of *P. Thunbergii* from South Africa, bearing clusters of ascocarps,  $\times 25$ . 6, one of these clusters showing deep apical furrows and pronounced tendency toward curvature,  $\times 11$ . 7, another cluster of the African material, showing the occasional extreme enlargement of the apical portion of the ascocarp,  $\times 11$ . FIGS. 8-12. *C. tropica*. 8, 9, clusters of ascocarps, from New Zealand,  $\times 11$ . 10, dehiscent ascocarps from South America,  $\times 11$ . 11, a twig of *P. totara* from New Zealand, with dense clusters of spermogonia,  $\times 11$ . 12, clusters of immature ascocarps from the Philippine Islands, showing the apical dimple,  $\times 11$ .

a more or less dumb-bell shape, our specimens from there are all referable to *C. tropica*. Hennings<sup>9</sup> reported *C. uberata* from Australia in 1903, but we had not seen material from there until 1935, when Lilian Fraser sent us collections from New South Wales showing the species in all stages of development. Photographs of some of her specimens are shown in figures 1-4 for comparison with the South African material, illustrated in figures 5-7. The ascocarp varies considerably in form in different collections. In some specimens its swollen, apical portion is considerably larger than the basal. The dumb-bell shape and the shaggy appearance of the apex are, however, sufficiently characteristic of *C. uberata* to render confusion with other species unlikely.

2. *CORYNELIA NIPPONENSIS* Fitzp. Mycologia 12: 253. 1920.

TYPE: material of *Podocarpus macrophylla* Don., collected in Japan, was received at the Royal Botanic Gardens at Kew, January, 1893, from the Science College of the Tokyo Imperial University. George Massee noticed material of *Corynelia* on some of the leaves and transferred them to the cryptogamic herbarium. A part of the specimen was deposited at the New York Botanical Garden. The writer studied it there, and later received a portion of the material from Kew for comparison. The species, *C. nipponensis*, was then erected on this single collection. Fifty years have now passed since the fungus was collected and twenty-two since the species was described. Meanwhile, no other material has been found. In the original diagnosis of *C. nipponensis* emphasis is placed on the turbinate shape of the ascocarp. The possibility that this represents merely a variation within the limits of *C. uberata* has been considered, but until material of intermediate character is found, it seems best to retain *C. nipponensis* as a distinct species. Although the ascocarps are admittedly immature, it should be emphasized that much young material of *C. uberata* has been examined without the discovery in any collection of characteristically turbinate individuals.

<sup>9</sup> Hedwigia 42: 73. 1903.

(FIG. 27, 28)

Stroma sometimes circular, but more commonly elongated at right angles to the long axis of the leaf, erumpent through a transverse slit, bearing over the exposed surface a compact cluster of ascocarps containing as many as forty individuals; ascocarps turbinate, not fully mature in the specimen studied, and in no instance showing dehiscence; the broad, smooth apex rounded and traversed by a shallow furrow, which evidently marks the line of dehiscence; asci (p. sp.)  $30-42 \times 17-27 \mu$ , 8-spored; ascospores  $9-11 \mu$  in diam.

3. *CORYNELIA TROPICA* (Auersw. & Rab.) Starb. Ark. Bot. 5: 18-20. 1905.

*Endohormidium tropicum* Auersw. & Rab. Hedwigia 8: 89. 1869.

*Trullula tropica* Sacc. Syll. Fung. 3: 732. 1884.

*Corynelia clavata* f. *andina* P. Henn. Hedwigia 36: 230. 1897.

TYPE: Rab. Fungi Eur. 1261.

(FIG. 8-12)

Stromata scattered or in linear series along the midrib or margin of the leaf, frequently confluent to form a long, narrow, stromatic cushion; spermogonia and ascocarps borne usually on different stromata; spermogonia globose to irregularly compressed or confluent, densely crowded, forming semiglobose to tubercular masses; young ascocarps conical or irregular from crowding, less uniform in shape in their later stages than in other species, usually becoming characteristically barrel-shaped or short cylindrical, in some individuals indefinitely constricted in the middle zone to give a slightly hour-glass shape, in others retaining the conical form to maturity; when barrel-shaped, the upper end more or less flattened and umbilicate in young stages, the sides marked by a half dozen or more parallel, longitudinal ridges, and the whole surface roughened in such a fashion as to appear rimose; the barrel shape finally lost in many individuals through further development of the upper portion of the ascocarp, which may undergo considerable enlargement and form a broad, somewhat laterally compressed beak terminating in a rather smooth, rounded ridge bearing a transverse groove along its crest; the beak in dehiscence opening widely; the lips sometimes having the brownish, pulverulent appearance typical of the ruptured apex of the ascocarp in other genera; asci 8-spored



except in rare cases of abnormality; ascospores 9–13  $\mu$  (commonly 11) in diam.

The original description of the species was based on material collected in South America, at Valdivia, Chile, near the fortieth parallel of south latitude. Though other specimens were later found farther north, the specific name is a misnomer, in that the fungus is less tropical in distribution than any other species of *Corynelia*. It is known, as yet, only from Chile, the Philippine Islands, and New Zealand. Our former diagnosis and the photographs illustrating it, were less satisfactory than those provided for the other species. Most of the specimens which had then been examined were fragmentary and contained few mature ascocarps. Subsequently a number of additional specimens have been studied, including abundant material from New Zealand where the species is common and widely distributed. All the specimens from the Philippines as yet seen by us were collected on *Podocarpus costata*, on Mt. Banahao near Manila. Though a few asci and ascospores are to be found in them most of the ascocarps are immature and marked by the apical umbilicus above mentioned.

4. *CORYNELIA OREOPHILA* (Speg.) Starb. Ark. Bot. 5: 18–20. 1905.

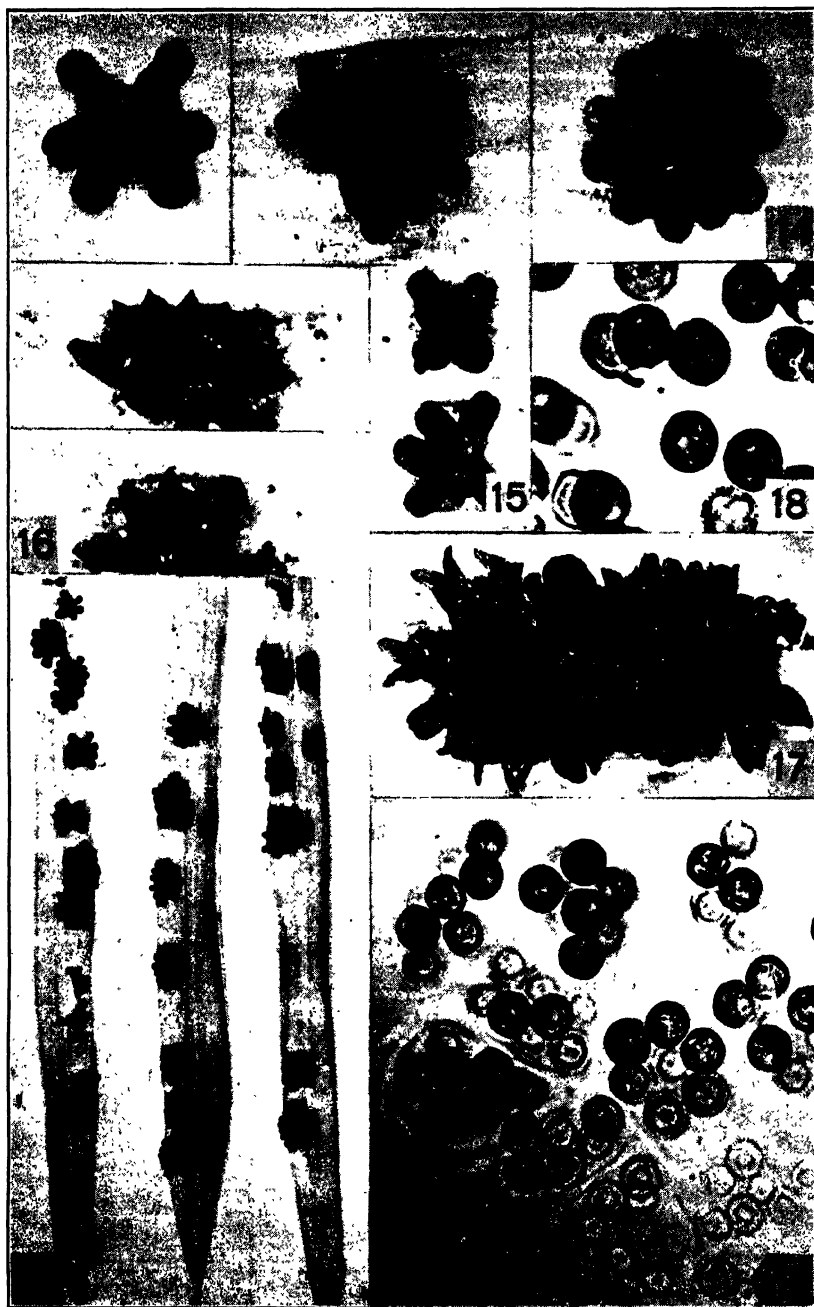
*Alboffia oreophila* Speg. Anal. Mus. Nac. Buenos Aires 6: 295 1898.

TYPE: The original material on which Spegazzini based *A. oreophila* was collected in 1897 in Argentina on *Podocarpus angustifolia*. The specimen had disappeared before 1920, when Spegazzini sent the writer another collection from Argentina believed by him to be the same fungus. This was found to agree with the material on which Starbäck had based his transfer of the species to *Corynelia*. The latter was collected on the same host in Bolivia, and was deposited as No. 301 in the Herbarium of Robert Fries, at Stockholm (Riksmuseets Botaniska). In addition to these collections, the writer has studied eight others. Three of them were made in Costa Rica. The rest are from South America, the fungus having been seen from Argentina, Chile, Bolivia, Brazil, and Colombia. Various species of *Podocarpus* have been reported as hosts.

(FIG. 25, 26)

Stroma covered with an irregularly arranged group of ascocarps or visible as a prominent, characteristically roughened, sterile cushion, surrounded by a single row of approximately horizontal, radiating individuals as in *C. brasiliensis*; ascocarp characteristic in shape, most closely resembling that of *C. jamaicensis*; the lower half subcylindrical, tapering slightly upward, its surface roughened like the stroma; the upper half smooth to shiny, typically trilobed and trisulcate, in transverse section triangular, tapering slightly downward, giving the ascocarp a somewhat constricted middle zone; the apex subtruncate and centrally depressed; the three furrows united in this depression and running far down the sides between the lobes; dehiscence taking place along the entire length of the furrows making the upper half of the ascocarp deeply trileft; the three lobes separating and turning back giving a 3-pronged aspect; occurrence of bilobed or quadrilobed individuals rare; ascocarps closed or wedge-shaped in age, as in *C. brasiliensis*, not observed; ascus (p. sp.)  $34-42 \times 22-30 \mu$ , typically 8-spored; a few 6-spored asci, fewer 5-spored ones, and a single 2-spored one seen, but such variations not correlated with the number of lobes of the ascocarp; ascospores  $10-13.5 \mu$  (mostly 12-13) in diam.

The four species, *C. oreophila*, *C. brasiliensis*, *C. jamaicensis*, and *C. portoricensis*, are known only from the Western Hemisphere, and are evidently more closely related to each other than to the rest of the genus. In all of them the apex of the ascocarp is definitely lobed, with grooves lying between the lobes and running far down the sides. The two species, *C. oreophila* and *C. brasiliensis*, with typically 8-spored asci, have been found only on the mainland of South and Central America. The other two, *C. jamaicensis* and *C. portoricensis*, with few-spored asci have been reported only from the West Indies. These four clearly had a common ancestry and have probably undergone gradual divergence in morphology as the geographical range has altered. Their development along different lines, from ancestral stock in which the ascocarp was bilobed and the asci 8-spored, is regarded as probable, and this hypothesis was elaborated in our earlier paper. Though admittedly closely related, the four species today are sharply demarcated, and there has been no accumulation of data from later collections to indicate that intergradation between them occurs.



FIGS. 13-19.

5. *CORYNELIA BRASILIENSIS* Fitzp. Mycologia 12: 257. 1920.

TYPE: Material collected in the State of São Paulo, Brazil, December, 1896, by Fritz Noack and sent to Elam Bartholomew at Stockton, Kansas, by P. Sydow under the name *C. oreophila*. A portion of the specimen, loaned to us by Bartholomew, was found to be an undescribed species, and was designated as the type of *C. brasiliensis*. Two additional specimens of the same collection in the herbarium of H. Rehm, at Stockholm, were examined. The label on the type specimen states that the collection was made near San Francisco dos Campos, but H. P. Krug of the Instituto Agronomico do Estado de São Paulo at Campinas has written us that no place of that name is known in the State of São Paulo or elsewhere in Brazil. He suggests that S. José dos Campos was perhaps meant. Before the species was described, another collection of material, made by Ule in Brazil and deposited in Rehm's herbarium, was compared with the type and found to be the same. More recently, a third collection was made for us by H. P. Krug (No. 1192) in São Paulo, at Faz. de Guarda, Campos do Jordão, September 25, 1935, on *Podocarpus Lambertii*. The material, received in extraordinary abundance, shows the fungus in all stages of development. As examination of this collection reveals that the original description was based on aged specimens and gives a false conception of the shape of the ascocarp, the following considerably emended diagnosis, based on the three known collections, is presented.

(FIG. 13-19)

Ascocarps sometimes covering the entire surface of the stroma as a crowded, irregularly arranged group, but more typically confined to its margin, and forming there a single row of horizontal, radiating individuals, bordering a prominent, central, sterile

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FIGS. 13-19. *Corynelia brasiliensis* on *Podocarpus Lambertii*. 13, leaves bearing ascocarps,  $\times 2\frac{1}{2}$ . 14, three stromata, each bordered by a row of nearly horizontal, radiating, bilobed ascocarps,  $\times 11$ . 15, two small clusters of immature ascocarps, each containing a trilobed individual,  $\times 11$ . 16, stromata bearing aged, closed, wedge-shaped ascocarps,  $\times 11$ . 17, two crowded stromata, each bordered by a row of ascocarps,  $\times 11$ . 18, mature ascopores showing echinulate surface and circular lighter-colored areas marking the position of germ-pores,  $\times 730$ . 19, asci of various ages; spores more mature toward the top,  $\times 510$ .

cushion; the basal half of the ascocarp considerably roughened and in shape similar to that of *C. oreophila*; the upper half smoother and typically bilobed; trilobed individuals occurring, but less commonly than in *C. portoricensis*; quadrilobed or pentilobed ascocarps not observed; the bilobed individuals similar in gross aspect to those of *C. portoricensis*, but stouter and with less tendency toward lateral compression above; ascocarp in dehiscence opening widely, and, after dissemination of the ascospores, frequently standing wide open and empty, revealing the lighter colored, reddish-brown inner surface of the wall; the recurved lips, however, often tending to come together again so that the emptied ascocarp in age is tightly closed; apex of these aged, closed ascocarps wholly different in shape than before dehiscence, in that the lips fail to regain their former position and instead come together in such a fashion as to form a definite wedge; asci typically 8-spored; ascospores 11–12  $\mu$  in diam.

The species is known only from Brazil, and *Podocarpus Lambertii* is the only definitely identified host. Field observations by Krug indicate that attacked plants are smaller and somewhat chlorotic. He collected the fungus at an altitude of about 1500 meters where the host grows most abundantly. He writes: "As you can see in the material sent to you, the perithecia resemble very closely those of *C. portoricensis*, becoming wedge-shaped only in age."

6. *CORYNELIA JAMAICENSIS* Fitzp. Mycologia 12: 262. fig. 6, 7. 1920.

TYPE: The species was based on material collected, Aug. 10, 1896, by Wm. Harris, on *Podocarpus purdieana*, on Mt. Diablo, Jamaica, near the hotel Holly Mount, and sent to us in 1918 by S. F. Ashby, then Microbiologist of the Department of Agriculture at Kingston. Additional material of the same collection deposited at the New York Botanical Garden as *Flora Jamaicensis*, No. 6629, was also seen. Another collection, made in Cuba in 1924, was recently encountered by the writer on material of *Podocarpus* in the phanerogamic herbarium at the New York Botanical Garden.

(FIG. 23, 24)

Stroma bearing several to many ascocarps in a crowded, irregularly arranged group, not exposed to view as a prominent cushion

surrounded by a marginal row of radiating individuals; ascocarp resembling that of *C. oreophila*, though usually somewhat smaller, chiefly trilobed as in that species, but quadrilobed individuals considerably more numerous, and pentilobed ones occasionally found; bilobed ones not yet observed; dehiscence occurring along all the grooves, a quadrilobed individual, for example, having a 4-pronged apex after its rupture; asci (p. sp.)  $28-42 \times 15-27 \mu$ , mostly 3-spored; the others chiefly 2-spored; asci with more than three spores rare; one containing eight normal spores not yet observed; normal, mature ascospores  $11-15 \mu$  in diam.

In the possession of typically trilobed ascocarps the species most closely approaches *C. oreophila*, but the tendency toward formation of a larger number of lobes is more pronounced. The characters of the asci and ascospores are essentially the same as in *C. portoricensis*, there being perhaps more 1-spored asci here than in that species.

7. *CORYNELIA PORTORICENSIS* Fitzp. Mycologia 12: 259. 1920.

*Corynelia clavata* var. *portoricensis* Stevens, Ill. Acad. Sci. Trans. 10: 178-181. 1917.

TYPE: Porto Rican Fungi, No. 784, received from the herbarium of the University of Illinois, collected, October 20, 1913, near Maricao, Porto Rico, on *Podocarpus coriacea*, by F. L. Stevens. Two other extremely abundant collections of the fungus from Maricao on the same host were studied by the writer before the species was erected. One of these was made, April 2, 1913, by Britton, Stevens, and Hess, the other, March 22, 1916, by Whetzel and Olive. The species is known only from the type locality.

(FIG. 20-22)

Ascocarps chiefly bilobed, but one or more trilobed individuals often centrally placed in the cluster of bilobed ones; quadrilobed ascocarps not yet seen; the trilobed ascocarps very similar to those of *C. oreophila*; the bilobed ones greatly resembling those of *C. brasiliensis*, but somewhat longer and typically more slender, also tending to be more flattened laterally in the upper lobulate portion; the lower part of the ascocarp roughened, subcylindrical, and tapering upward; the upper part smoother, dull to shiny, and tapering downward giving the ascocarp a somewhat narrowed middle zone; the trilobed individuals apically subtruncate and centrally depressed,



FIGS. 20-28.

the three grooves meeting in the depression and running far down the sides between the lobes; the bilobed individuals clavate above, the apex rounded, not angular, crossed by a prominent furrow which runs far down the two broader sides, in some cases extending practically to the base; dehiscence of trilobed individuals as in *C. oreophila*, the upper half of the ascocarp becoming deeply trileft; dehiscence of bilobed individuals taking place in some cases along the entire length of the groove, the two lobes pulling apart and turning backwards exposing much of the interior of the ascocarp, in other instances occurring only at the apex, a relatively small slit being formed; the lips in neither case observed to close together again in age to form a wedge as in *C. brasiliensis*; asci not differing in the two types of ascocarp, typically 3-spored, frequently 2-spored, and occasionally 1-spored; asci with eight fully formed spores not seen; normal ascospores 10.5–16.5  $\mu$  (usually 12–13.5) in diam.; the species in its possession of few-spored asci differing pronouncedly from *C. brasiliensis*, though in gross aspect strikingly similar.

2. *TRIPOSPORA* Sacc. in Berl. & Vogl. Addit. Syll. Fung. 194. 1886.

*Tripocorynelia* Kuntze, Revis. Gen. Plant. 3: 538. 1893.

TYPE SPECIES, *Corynelia tripos* Cooke.

Stromata rounded to elongate, not scattered, arranged in a definite row parallel to the long axis of the leaf, chiefly along the midrib, or similarly along a twig, becoming crowded and confluent, bearing decanter-shaped ascocarps interspersed with irregularly hemispherical spermogonia; ascocarp sessile; composed of a basal flask and a conical to cylindrical beak; apex of beak at maturity perforated and dilated by the extruding ascospores to funnel-form; the mass of spores giving the tip the aspect of an enlarging pul-

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FIGS. 20–22. *Corynelia portoricensis*. 20, three clusters of ascocarps; apices chiefly bilobed, but several trilobed,  $\times 11$ . 1, three clusters of somewhat more mature ascocarps showing dehiscence by transverse cleft along the line of the apical groove; the small, lighter-colored circles at the tips of several individuals being merely high lights in the photograph,  $\times 11$ . 22, asci and spores,  $\times 510$ . FIGS. 23, 24. *C. jamaicensis*. 23, a cluster of unruptured ascocarps, chiefly trilobed, a few quadrilobed,  $\times 11$ . 24, asci with mature spores,  $\times 730$ . FIGS. 25, 26. *C. oreophila*. 25, pulvinate stroma bordered by a radiating row of almost horizontal ascocarps,  $\times 11$ . 26, a stroma bearing a dehiscent, three-pronged ascocarp,  $\times 11$ . FIGS. 27, 28. *C. nipponensis*. Clusters of nearly mature, unruptured ascocarps, some showing transverse apical groove,  $\times 11$ .



verulent knob, and finally, as the funnel expands, filling it so completely that it becomes a broad convex disc; ascus 8-spored; ascospores characteristic in shape, resembling a caltrop, with 4 (rarely 5) stout, subconic lobes radiating from a rounded central portion, hyaline to light brown when young, becoming darker brown to almost black and opaque at maturity, thick-walled, unicellular, crowded; the radiating lobes closely overlapping to occupy the minimum space in the ascus.

#### KEY TO SPECIES OF TRIPOSPORA

- A. Ascocarp smaller in all its dimensions than in the following species; beak much shorter; ascospores mostly 23–26  $\mu$  in diam., with more slender, more uniformly tapering lobes .....1. *T. tripos*
- B. Ascospores mostly 26–32  $\mu$  in diam.; lobes slightly constricted at the base, broadest at the mid-portion, and tapering abruptly toward the tip .....2. *T. macrospora*

#### 1. TRIPOSPORA TRIPOS (Cooke) Lindau, in E. & P. Nat. Pfl. 1<sup>1</sup>: 413. 1897.

*Corynelia tripos* Cooke, Grevillea 8: 34. 1879.

*Tripospora Cookei* Sacc. in Berl. & Vogl. Addit. Syll. Fung. 194. 1886.

*Tripocorynelia tripos* Kuntze, Revis. Gen. Plant. 3: 538. 1893.

TYPE: Specimen in herbarium of Cooke, collected at Cape of Good Hope, S. Africa, near Somerset-East, on *Podocarpus elongata*, by P. MacOwan; compared at Kew by Miss E. M. Wakefield with No. 3150 of Rabenhorst-Winter, Fungi europaei and found to be the same, the latter being *co-type* material. The writer has examined portions of this collection in several institutions and has studied other specimens from Cape Province and Natal.

(FIG. 34–37)

Ascocarps arising usually along the sides of the elongate stromatic cushion; the two rows, with beaks pointing in opposite directions, having a regular and attractive appearance; ascocarp consisting of a globose to ovoidal, roughened, sessile flask, containing the ascigerous locule, and a glabrous, shiny, conical to short-cylindrical beak; apex of beak rounded, blunt, and umbilicate, finally perforate and opening widely to shallow funnel-form; the extruding ascospores filling the funnel to overflowing and forming a convex disc of dark brown, pulverulent aspect, which

equals or somewhat exceeds in diameter the basal portion of the ascocarp; complete dissemination of the spores later exposing the lighter colored inner wall of the funnel, which then appears as a reddish-brown rim bordering the orifice; ascocarp smaller in all its dimensions than in the following species, especially with a much shorter beak; ascospores at maturity dark brown to black and quite opaque,  $15-32\ \mu$  (mostly  $23-26$ ) in diam., measured from the tip of one lobe to that of another, decidedly smaller than in the following species, and differing somewhat in shape, the lobes being more slender and tapering more uniformly from base to apex; species parasitic on the leaves and green twigs of *Podocarpus elongata* and *P. Thunbergii* in South Africa, not known to the writer on other hosts or from other localities; South American collections, earlier included here, now made the basis of the following new species.

## 2. *Tripodopora macrospora* sp. nov.

TYPE: Specimen collected by H. P. Krug, Sept. 25, 1935, at Fazenda da Guarda, Campos do Jordão, Brazil, on *Podocarpus Lambertii* (Herb. Fitzpatrick 2055). The following additional collections have also been examined; a specimen collected by P. Dusén, at Serrinha, Paraná, Brazil, and sent to us by L. Romell; another from Serra Geral, Brazil, collected by Ule and deposited in the herbarium of Rehm (No. 1744, 1747); a third collected by S. Venturi, Cerro del Campo, Tucuman, Argentina, and sent to the Missouri Botanical Garden (No. 7725).

(FIG. 29-33)

Ascocarpus nec forma nec ordine partium a typi distat verum aliquanto longius productus est; rostrum multo longius prostat et flexuosius est; ascospori maiores sunt, diametri  $20-36\ \mu$  (plurimi vero  $26-32$ ), ne forma quidem simillimi; lobi sporidiorum in infima parte paululum constrictiores; in media parte latissimi, in extrema parte subito exiliores fiunt, typo crassiores et rigidiores sunt.

Ascocarp resembling that of the type species, but considerably larger in all its dimensions; beak much longer, more flexuous, and more erect in habit; ascospores larger,  $20-36\ \mu$  (mostly  $26-32$ ) in diam., measured from the tip of one lobe to that of another, and differing from those of the type somewhat in shape; spore lobes slightly constricted at the base, broadest in the mid-portion, tapering abruptly toward the tip, and in general stouter, more rigid, and less graceful than in the type species.



FIGS. 29-37.

### 3. *Coryneliospora* gen. nov.

TYPE SPECIES, *Capnodium fruticolum* Pat.

Ascogonium et forma et aperturae specie *Triposporae* par est; ascus octo sporidiorum est; ascospori *Coryneliae* similissimi nec tamen ex omni parte spherici; magnitudine quoque magis variant.

Ascogonium consisting of a sessile flask, tapering upward into a cylindrical beak; apex of beak at maturity perforated and dilated to funnel-form by the extruding ascospores; ascospores echinulate, thick-walled; some large and globose, and essentially identical with those of *Corynelia*; others small, flattened, or irregular.

In the form and aspect of the ascogonium the genus closely approaches *Tripospora*. It differs from *Corynelia* chiefly in method of dehiscence, from *Lagenulopsis* in the echinulate character of the spores, and from both of them in that the species does not occur on *Podocarpus*. Our reasons for not recognizing the genus *Lagenula* Arnaud, are elaborated in the second part of this paper in connection with the discussion of *Caliciopsis*.

#### 1. *Coryneliospora fruticola* (Pat.) comb. nov.

*Capnodium fruticolum* Pat., Jour. de Bot. 3: 258. 1889.

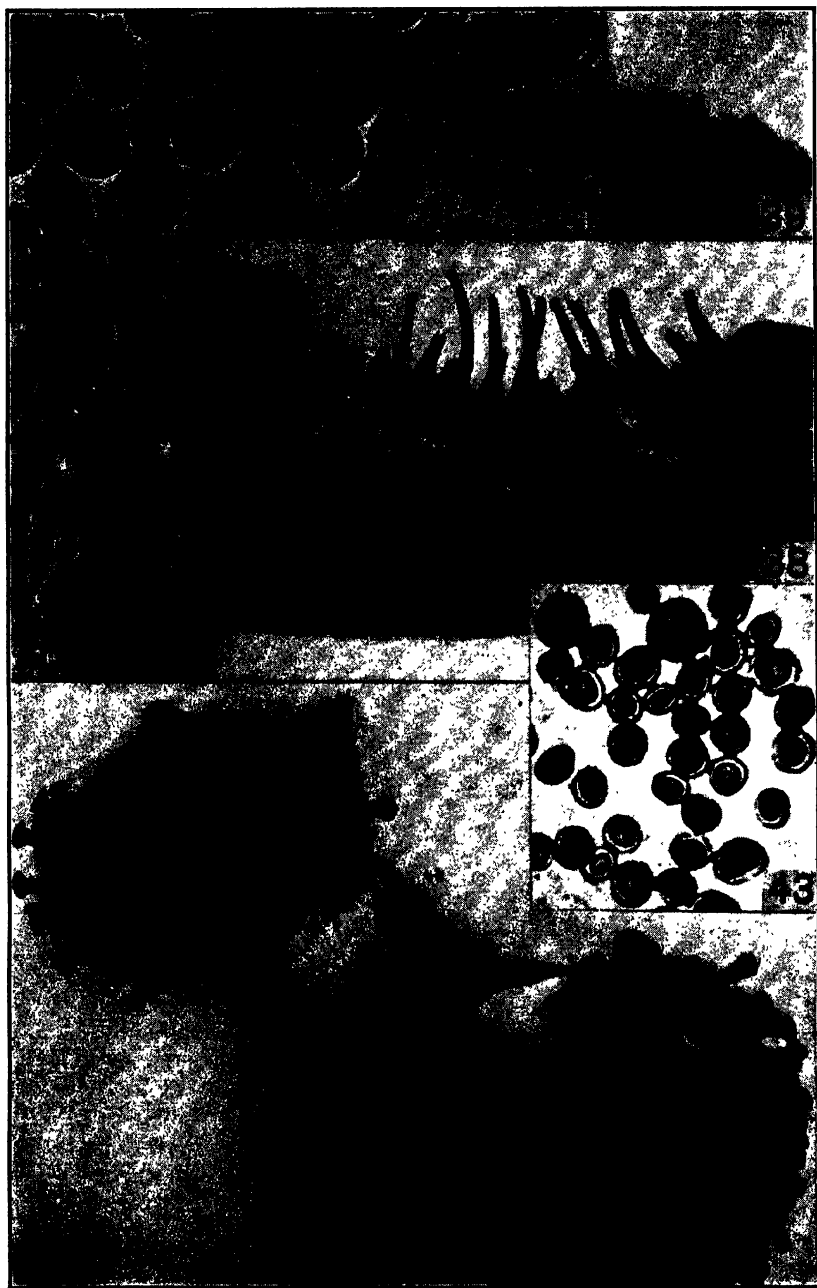
*Corynelia carpophila* Syd., Engler Bot. Jahrb. 45: 264. 1910.

*Corynelia fruticola* (Pat.) v. Höhnelt, Sitzber. Kais. Akad. Wiss. 120: 450. 1911.

*Lagenula fruticola* (Pat.) Arn. Ann. Epiphy. 16: 269. 1930.

TYPE: Original material of *Capnodium fruticolum*, in herbarium of Patouillard at Harvard University, on fruits of *Myrsine* sp.

FIGS. 29-33. *Tripospora macrospora*. 29, elongate stromata, bearing ascogonia on leaves of *Podocarpus*, nat. size. 30, mature ascogonia,  $\times 11$ . 31, ruptured ascogonia, the funnel-shaped apex of each filled with a pulverulent mass of extruding ascospores,  $\times 11$ . 32, mature, free ascospores,  $\times 180$ . 33, two asci, showing the compact arrangement of the eight stellate ascospores,  $\times 730$ . FIGS. 34-37. *T. tripos*. 34, a row of eruptive stromata bearing a double row of ascogonia,  $\times 11$ . 35, mature ascogonia as seen in lateral view, the funnel-shaped apex of each packed with extruding ascospores and having the aspect of a convex disc,  $\times 11$ . 36, mature ascogonia, the apex of each appearing as a shallow funnel; the reddish-brown, inner surface surrounding a narrow throat still filled with brownish-black ascospores,  $\times 11$ . 37, nearly mature ascospores, of smaller size and somewhat different shape from those of the preceding species,  $\times 180$ .



FIGS. 38-41. *Lagenulopsis bispora*. 38, stromata on leaf of *Podocarpus* bearing spermogonia and ascocarps,  $\times 11$ . 39, cluster of ascocarps showing

collected in southwestern China, in the Province of Yun-nam, by Delavay. The type specimen of *Corynelia carpophila* Sydow, collected by Lane Poole in the Transvaal, South Africa, on *Rapanea melanophleos* is the same fungus. Other specimens from South Africa on this host and one from India on *Myrsine africana* have been seen.

(FIG. 42, 43)

Stromata fructicolous, rounded, reaching 1 mm. in diam., commonly confluent to form a crust which sometimes completely encircles the fruit; surface of young stroma covered with densely crowded spermogonia, among which the ascocarps develop and protrude as radiating spines; spermogonium globose, provided with a prominent, apical, perforate papilla, and tapering at the base into a more or less evident stalk; spermatia hyaline, rod-shaped to allantoid,  $4-6 \times 1 \mu$ ; ascocarp decanter-shaped; the basal flask tapering upward into a cylindrical beak; apex of beak blunt, marked in early stages by a tiny umbilicus, later perforated and dilated by the extruding spores to shallow funnel-form; spore-mass forming an enlarging, pulverulent knob, which finally broadens into a thick, convex disc; complete dissemination of the spores exposing the lighter colored, reddish-brown, inner surface of the funnel; asci (p. sp.)  $20-25 \times 11-14 \mu$ , 8-spored; ascospores echinulate, thick-walled, brown, varying considerably in size and shape; large spherical spores,  $10.5 \mu$  in diam.

#### 4. *Lagenulopsis* gen. nov.

TYPE SPECIES, *Corynelia bispora* Fitzp.

Ascocarpus lecythi forma, sessilis, in exile rostrum exiens; apertura non differt a *Caliciopsis*; ascus duorum sporidiorum; ascospori globosi vel subglobosi, muris crassissimis, levibus, fulvis.

Stromata rounded, typically crowded, bearing radiating, spine-like ascocarps interspersed with smaller, inconspicuous spermogonia; mature ascocarp composed of a subconical, sessile flask, containing the ascigerous locule, and a long, slender beak; apex of beak in dehiscence perforated and dilated by the extruding ascospores to funnel-form; the funnel narrow and inconspicuous as in *Caliciopsis*, not broad and shallow as in *Tripospora* and *Corynelio-*

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the brown, apical knobs formed in dehiscence,  $\times 11$ . 40, two-spored asci; the ascospores of various ages,  $\times 730$ . 41, mature, free, extremely thick-walled ascospores,  $\times 730$ . FIGS. 42, 43. *Coryneliospora fruticola*. 42, fruits of *Rapanea melanophleos* bearing spermogonia and ascocarps on crowded to confluent stromata,  $\times 11$ . 43, mature ascospores, with the plane of focus raised to show the echinulate surface,  $\times 730$ .

*spora*; the spore-mass forming an inconspicuous, pulverulent brown knob; ascospores globose to subglobose, with an exceptionally thick, smooth, brown wall.

Differing from *Caliciopsis* in the much larger and far thicker-walled spores, in the typically sessile ascocarp, and in the occurrence on *Podocarpus*; allied by this host relationship with *Tripodospora* and *Corynelia*.

1. **Lagenulopsis bispora** comb. nov.

*Corynelia clavata* f. *macrospora* Sydow, Adolf Friedrichs  
Deutsche Zentral-Afrika-Exped. 1907-1908. 2: 100. 1910.

*Corynelia bispora* Fitzp. Mycologia 12: 242. 1920. ,

TYPE: Original material of *C. clavata* f. *macrospora* collected on *Podocarpus milanjanus* Rendle, deposited as No. 2547 in herbarium of Sydow, at Berlin.

(FIG. 38-41)

Stromata erumpent on the upper or lower surface of the leaf or emergent along its edge, in the latter case apparently bordering wounds made by chewing insects; spermogonium globose to subconical, apically umbilicate, finally perforate; spermatia hyaline, yellowish in mass, fusiform,  $5-8 \times 2 \mu$ ; ascocarp 1-2 mm. in length; ascus apparently constantly 2-spored; ascospores 11-15  $\mu$  in diam.

Sydow erected *Corynelia clavata* f. *macrospora* on a single collection of material received from central Africa in 1908. The writer examined a fragmentary portion of this collection, found the fungus to be actually very different from *C. clavata*, and erected on it the new species *C. bispora*. Attention was called to the 2-spored nature of the ascus, and to the resemblance of the ascocarp in shape and method of dehiscence to that of *C. fruticicola*. As we had never seen another specimen of the fungus, it was especially pleasing to receive an ample amount of material in 1933 collected in Jamaica in July of the preceding year by Professor Duncan S. Johnson. The above emended diagnosis is based chiefly on this Jamaican material. The asci and ascospores are indistinguishable from those of the type, and the fructifications agree in size and shape.

DEPARTMENT OF PLANT PATHOLOGY,  
CORNELL UNIVERSITY,  
ITHACA, NEW YORK

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## REVISIONARY STUDIES IN THE CORYNELIACEAE. II. THE GENUS *CALICIOPSIS*<sup>1</sup>

HARRY MORTON FITZPATRICK

(WITH 35 FIGURES)

5. *CALICIOPSIS* Peck, Ann. Rep. N. Y. State Mus. 33: 32. 1883.  
*Hyphotheca* Ellis & Ev., Jour. Myc. 1: 128. 1885.  
*Sorica* Giesenhagen, Ber. Deuts. Bot. Ges. 22: 191. 1904.  
*Lagenula* Arnaud, Ann. Epiphyt. 16: 267. 1930.

Type species, *Caliciopsis pinea* Peck.

Stromata scattered to crowded, in some species commonly confluent, erumpent as rounded to somewhat elongated cushions; the protruding stromatic surface early minutely lobed; the individual lobes transformed into spermogonia, or elongating into slender columns, which are here termed ascocarps; mature spermogonium sessile to short-stipitate, apically perforate; spermatia unicellular, elongate, hyaline to slightly yellowish; ascocarps one to several to a stroma, pushing up usually among the previously formed spermogonia as relatively more prominent, tapering spines; aspect of the mature ascocarp various in the several species due largely to difference in the position in the column of the swollen portion containing the ascigerous locule; this enlargement usually more or less median, but ranging from terminal to basal; when terminal, giving the mature, ruptured ascocarp an urceolate appearance; when basal to subapical, tapering above into a more or less elongate beak through which runs a narrow, cylindrical canal; in most species a considerable section of the column existing below the enlargement as a solid stalk; ascus (p. sp.) ovoidal to ellipsoidal with a long

<sup>1</sup> Part I appeared in MYCOLOGIA 34: 464. 1942.

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delicate stalk, 8-spored; ascospores ellipsoidal to globose or subfusiform, smooth, faintly yellowish to blackish-brown, progressively more mature toward the top of the locule where they are freed by deliquescence of the ascus walls and extrude through the exit canal; apex of the immature ascigerous column pointed or blunt, at maturity perforate and dilated to narrow funnel-form as the ascospores extrude and form a rather inconspicuous, terminal, pulverulent, brown, knob-shaped mass; branching or forking of the column occasionally seen; its proliferation to form a secondary column above the primary known only in one species.

The genus differs from the others of the family in its more slender, typically stipitate ascocarp and its smaller, thinner-walled ascospores. It differs from *Corynelia* in the type of dehiscence also, and from *Corynelia*, *Tripospora*, and *Lagenulopsis* in that none of its species occur on *Podocarpus*. Though several members of the genus have been found in the Southern Hemisphere or in the tropics, the species occur chiefly in north temperate regions. For the most part they are parasitic on coniferous or dicotyledonous hosts.

The genus *Caliciopsis* was erected by Peck in 1880 on *C. pinea*. Though the generic name selected indicates that he noted the resemblance of the ascocarp to that of *Calicium*, he realized that the species is not a lichen. He described it as one of the stipitate Discomycetes. Five years later Ellis established the genus *Hypsotheca* on three other species, *H. subcorticalis*, *H. calicioides*, and *H. thujina*. He was aware of the existence of *Caliciopsis pinea* and felt that his own species are closely allied to it, but in deference to Peck's opinion that it is discomycetous he avoided incorporating it in the Pyrenomycetes. The beaked nature of the ascocarp in his own species led him to place *Hypsotheca* in the Ceratostomataceae. Later the two genera were united by Rehm<sup>2</sup> in the Calicieae under the name *Caliciopsis*. To von Höhnelt<sup>3</sup> belongs the credit for first suggesting that the genus be incorporated in the Coryneliaceae.

Meanwhile, *Sorica* Giesenhagen<sup>4</sup> had been erected on *Capnodium maximum* Berk. & Curt., here included in *Caliciopsis*. Arnaud<sup>5</sup>

<sup>2</sup> Rab. Krypt.-Fl. 1<sup>a</sup>: 382. 1896.

<sup>3</sup> Sitz.-ber. Akad. Wiss. Wien 120: 149. 1911.

<sup>4</sup> Ber. Deuts. Bot. Ges. 22: 191. 1904.

<sup>5</sup> Ann. Ecole Nat. Agric. Montpellier, n. s. 12: 23. 1912.

included the four genera, *Sorica*, *Hypsotheca*, *Caliciopsis*, and *Corynelia* in the Caliciaceae. In recognizing *Hypsotheca* as distinct from *Caliciopsis*, he states that the ascospores are globose in the former and ellipsoidal in the latter. To make this basis of separation more satisfactory he transferred *H. calicioides* to *Caliciopsis*. In the writer's taxonomic treatment of the Coryneliaceae<sup>6</sup> the genus *Hypsotheca* was merged with *Caliciopsis*, little emphasis being placed on difference in spore shape in the four species thus brought together. The genus *Sorica* was recognized as distinct, the extraordinary phenomenon of proliferation exhibited by the ascocarp in its single species being accorded generic significance. Ten years later Arnaud<sup>7</sup> followed the writer in merging *Hypsotheca* in *Caliciopsis*, and in recognizing *Sorica* as distinct, but states that proliferation of the ascocarp in *S. maxima* is not sufficiently constant to serve as the basis of generic separation. Indeed he included in the genus another species, *S. clavata*, in which the phenomenon is wholly lacking. He says that *Sorica* differs from *Caliciopsis* in having globose ascospores. He continues to regard the fructification as an apothecium, and treats the Coryneliées as a subdivision of the Caliciaceae. Our observations indicate that the phenomenon of proliferation is always present in old specimens of *S. maxima*. It is of course absent in young material. Of the species included here by us in *Caliciopsis*, *C. Symploci*, described below as new, most closely approaches *S. maxima* in morphology. Our material of this species is all young, and in none of it has proliferation been observed, though the phenomenon is perhaps present in later stages. This case emphasizes the practical difficulty involved in attempting to maintain a separation between *Sorica* and *Caliciopsis* on this one feature alone, and we are now abandoning our earlier effort to do so. We do not find it feasible, however, to follow Arnaud in basing the generic separation on difference in ascospore shape. Though the spores of *S. maxima* are typically globose and those of *C. pinea* ellipsoidal, other species exhibit variation in form between these two types. As the entire aggregation of species involved is not large and as they constitute a

<sup>6</sup> Mycologia 12: 206-267. 1920.

<sup>7</sup> Ann. Epiphyt. 16: 235. 1930.

coherent unit of evidently related fungi, it now seems best merely to embrace all of them in *Caliciopsis*.

The genus *Lagenula* Arnaud must be discussed in this connection. It was conceived by its author to be intermediate between *Sorica* and *Tripodopora*, with globose spores and a sessile, decanter-shaped ascocarp. As erected, the genus embraced three species, *L. nigra*, *L. fructicola*, and *L. arrhiza*. The first named, designated by Arnaud as the type, had been included by him earlier in *Corynelia* as *C. juniperina*. The second had been treated by the writer as *C. fructicola*. The third was originally described as a species of *Capnodium*. Though Arnaud states that the ascocarp in *Lagenula* is wholly sessile, careful examination of material of *L. nigra* reveals that a definite stalk is sometimes present. It is to be seen in Arnaud's own drawings and is shown in our figure 18. Of greater significance, the species included in the generic concept show such great dissimilarity in spore characters that they can hardly be regarded as closely related.

In the taxonomic portion of the paper which follows, not all of the specimens examined during the investigation are listed. Brevity has been sought also by the use of capital letters in parentheses following the citations. These letters designate the institution and herbarium in which the specimens studied are to be found. The following letters have been used.

- A—Herbarium Charles Peck, N. Y. State Museum, Albany, N. Y.
- c—Herb. Dept. Plant Pathology, Cornell Univ., Ithaca, N. Y.
- D—Herb. Charles E. Fairman, deposited at Cornell Univ.
- F—the writer's personal herbarium, at Cornell Univ.
- H—Farlow Herb., Harvard Univ., Cambridge, Mass.
- K—Herb., Royal Botanic Gardens, Kew, England.
- N—Herb. New York Botanical Garden, N. Y. City.
- o—Herb. L. O. Overholts, State College, Pennsylvania.
- P—Museum Nationale d'Histoire Naturelles, Paris.

#### KEY TO SPECIES OF CALICIOPSIS

A. Ascospores ellipsoidal to subfusiform.

1. Ascigerous locule terminal to subterminal.

a. Ascospores less than  $7\mu$  in length; species occurring only on conifers.

- (1) Ascigerous locule essentially terminal; the mature ruptured ascocarp having consequently an urceolate appearance; ascospores  $5-6 \times 3 \mu$ .  
1. *C. pinea* (FIG. 1-5)
- (2) Ascigerous locule subterminal; the ruptured ascocarp retaining the definitely beaked aspect; ascospores much smaller,  $4 \times 2 \mu$ .  
2. *C. Pseudotsugae* (FIG. 6, 7)
- b. Ascospores considerably larger,  $7.5-10 \times 4-5 \mu$ ; ascigerous locule terminal to subterminal; species known only on *Tilia*.  
3. *C. Tiliae* (FIG. 14, 15)
2. Ascigerous locule median to submedian; ascospores  $6-8 \times 3.5-5 \mu$ .  
4. *C. calicioides* (FIG. 11-13)
- B. Ascospores globose to ovoidal.
  1. Ascospores somewhat variable in shape, typically intermediate between globose and ellipsoidal.
    - a. Ascocarp definitely beaked; ascospores  $4-5 \mu$  in diameter.  
(1) Ascigerous locule subterminal above a long stalk.  
5. *C. subcorticalis* (FIG. 8-10)
    - (2) Ascocarp relatively short; ascigerous locule usually basal.  
6. *C. nigra* (FIG. 16-19)
    - b. Ascocarp not beaked, clavate to urceolate; ascigerous locule terminal; ascospores  $8-10 \mu$  in diameter.  
7. *C. clavata* (FIG. 20-24)
  2. Ascospores spherical or nearly so.
    - a. Ascospores less than  $5 \mu$  in diameter.
      - (1) Ascocarp short-beaked; apical proliferation not yet observed.  
8. *C. thujina* (FIG. 25, 26)
      - (2) Ascocarp with a long beak, after dehiscence undergoing apical proliferation.  
9. *C. maxima* (FIG. 27-32)
    - b. Ascospores  $5.5-7 \mu$  in diameter; ascocarp with a long beak and a longer stalk; apical proliferation not yet observed.  
10. *C. Symploci* (FIG. 33-35)

1. CALICIOPSIS PINEA Peck, Ann. Rep. N. Y. State Mus. 33: 32. 1880.

*Calicium stenocyboides* Nyl. Flora 65: 451. 1882.

*Cyphelium stenocyboides* Arnold, Lichenes Monac. Exsic. 417. 1895.

*Caliciopsis stenocyboides* Rehm, in Rab. Krypt.-Fl. 1<sup>8</sup>: 389. 1896.

TYPE: Material in the herbarium of Peck, collected by him at Charlton, N. Y., July 1880, on *Pinus Strobus* (A); a portion de-

posited at the New York Botanical Garden; both examined by us (F 1688).

**OTHER MATERIAL EXAMINED:** Numerous collections of the species have been made by the writer near Ithaca, N. Y., on *P. Strobus* (F, c). It occurs in the eastern United States on this and various other species of pine (*P. rigida*, *P. pungens*, *P. echinata*, *P. virginiana*), and was found in Germany on *P. pumilo* (H). It was collected by Overholts<sup>8</sup> in Pennsylvania on *Tsuga canadensis* (o 11029), and is reported by Rehm<sup>9</sup> from Germany on *Abies*. We have not seen Rehm's material, but the Overholts specimen agrees with the fungus on pine. Material on the various species of pine is indistinguishable.

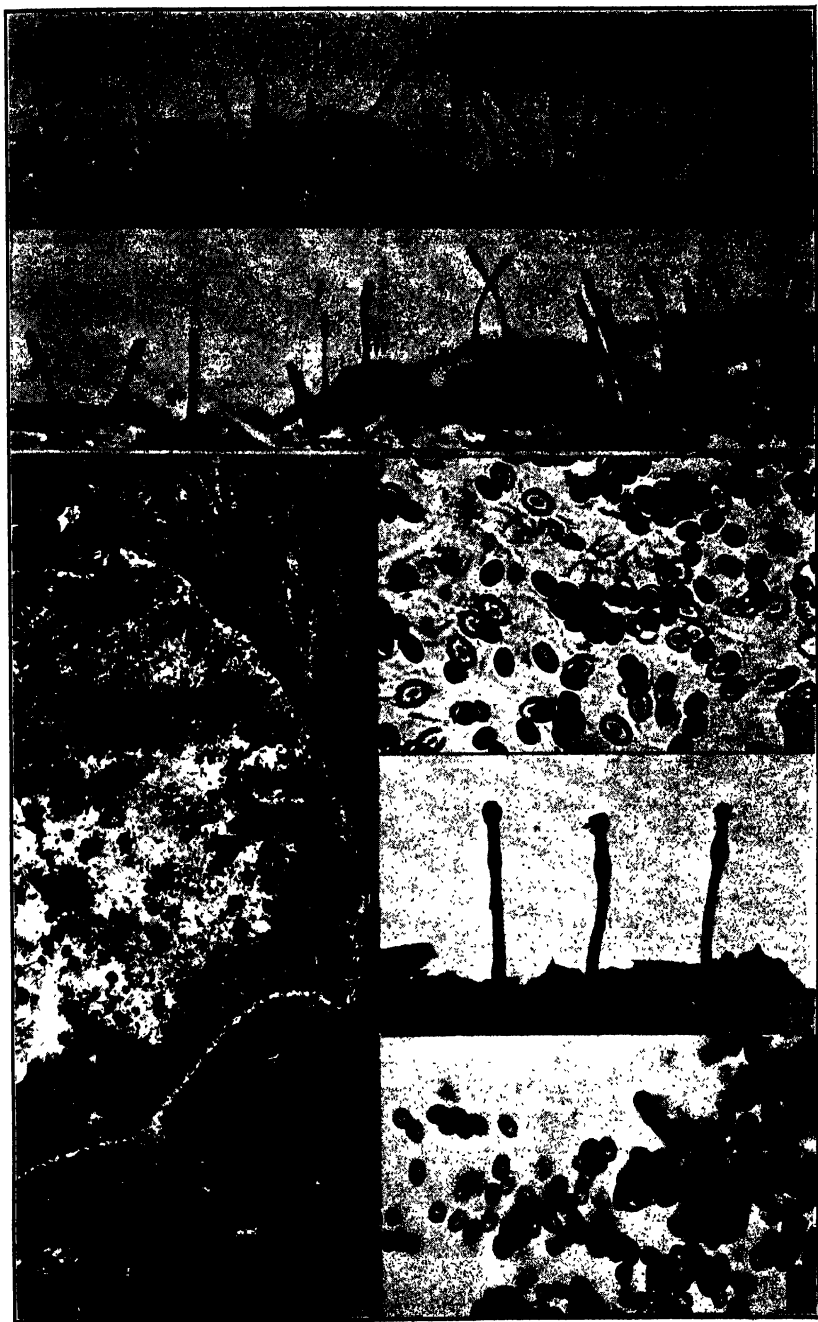
Stromata initiated beneath the surface of the bark as small, more or less circular, often confluent, flat cushions, erumpent, bearing over the protruding surface a crowded group of minute, hemispherical to subpyriform lobes which develop into spermogonia and ascocarps; the former maturing first and commonly covering the stroma as a densely crowded cluster; spermogonium globose to ovoidal, apically perforate; spermatia rod-like to allantoid, hyaline to pale yellowish, 2.5–3.5  $\mu$  in length, borne on conical to bottle-shaped spermatophores; a relatively smaller number of stromatic lobes pushing out among the spermogonia and projecting far above them in a loose fascicle as spine-like, cylindrical, ascigerous columns; apex of column finally enlarging into an elongate, fusiform swelling within which an ascigerous locule differentiates; mature column often somewhat curved or flexuous, averaging 1.5 mm. in length, occasionally branched or forked; ascigerous swelling 125–175  $\mu$  in lateral diam., essentially terminal, with little or no beak, when dry often laterally collapsed, in dehiscence the accumulation of a fuzzy, brownish plug of extruding spores giving an urceolate form and a striking resemblance to the capsule in such mosses as *Hypnum*; column below swelling constituting a long, slender, cylin-

<sup>8</sup> Mycologia 22: 235. 1930.

<sup>9</sup> Rab. Krypt.-Fl. 1<sup>o</sup>: 382. 1896.

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FIGS. 1–5. *Caliciopsis pinea*. 1, immature unruptured ascocarps,  $\times 11$ . 2, 3, mature ascocarps,  $\times 11$ . 4, clearly outlined, depressed canker on bark of *Pinus strobus*, showing scattered, erumpent, black stromata; surface of canker somewhat overrun by a thin layer of resin,  $\times 3$ . 5, asci and mature ascospores,  $\times 730$ . FIGS. 6, 7. *C. Pseudotsugae*. 6, lateral view of three ascocarps, each borne on a separate stroma emergent from the bark of *Pseudotsuga taxifolia*,  $\times 11$ . 7, asci and mature ascospores,  $\times 730$ .



FIGS. 1-7.

dricul, solid stalk, 100–125  $\mu$  in diam., usually broadened somewhat toward the base; ascus (p. sp.) ellipsoidal,  $20 \times 8 \mu$ ; ascospores chiefly ellipsoidal,  $5-6 \times 3 \mu$ .

In labeling plate 18 of our earlier paper<sup>10</sup> the numerals 48 and 49 were unfortunately interchanged, leaving the impression that the spores of *C. pinea* are spherical and those of *Sorica maxima* elongate, when the reverse is true. Though field observations indicate that *C. pinea* is parasitic on the various trees on which it occurs, proof based on inoculations<sup>11</sup> is available only in the case of *Pinus Strobus*. On this host definite cankers are formed on the trunk and larger branches, and attacked saplings are apparently sometimes killed.

## 2. *Caliciopsis Pseudotsugae* sp. nov.

TYPE: Collected by J. R. Hansbrough (No. 185) at Daisy Lake, British Columbia, June 22, 1930 (F 2044). Other specimens collected by him in British Columbia and Oregon have been found to be the same. The material was identified tentatively by the writer as *C. pinea* Peck and in consequence was mentioned under that name by J. S. Boyce.<sup>12</sup>

Columna stromatica *C. pinea* similis visui obvia, verum maior et typi magis solitarii; maxima 2 mm. est; stilus diametri 250  $\mu$  est; locus subapicis; columnae summa pars in rostrum exile exit, non urceolata; ascospori ad ellipsis formam accedunt, fere  $4 \times 2 \mu$ .

Stromata occurring on the twigs and small branches of Douglas fir, *Pseudotsuga taxifolia* (Lam.) Britton, usually in definite association with small, oval to ellipsoidal, sharply delimited cankers, initiated as small, scattered cushions in or just beneath the bark, chiefly in or bordering the callus at the margin of the canker; each stroma giving rise to one to several small spermogonia and usually to only a single ascocarp; the latter protruding as an isolated, rigid, black spine which elongates into a slender, straight to flexuous, cylindrical column; column attaining a length of 2 mm., tapering to a somewhat broadened base, and provided with a prominent, ovoid to fusiform, subterminal, ascigerous enlargement, which has a maximum lateral diameter of approximately 250  $\mu$  and in dried specimens is usually laterally collapsed; portion of column above

<sup>10</sup> Mycologia 12: 206–267. 1920.

<sup>11</sup> Mycologia 28: 201. 1936.

<sup>12</sup> Forest Pathology. p. 267. 1938. McGraw-Hill Book Co.

enlargement tapering toward the apex to form a definite beak, that below constituting a long stalk,  $150\ \mu$  in diam.; the extruding mass of ascospores in dehiscence forming a pulverulent, brown plug often exceeding  $250\ \mu$  in diameter; asci (p. sp.) approximately  $14 \times 7\ \mu$ ; ascospores ellipsoidal,  $4 \times 2\ \mu$ .

Though this species resembles *C. pinca* in gross aspect and in its occurrence on a coniferous host, there are several points of pronounced difference. The stromatic column is larger in all its dimensions, and more typically solitary. The ascigerous locule is subapical, giving the tip of the column a beaked rather than an urceolate aspect. The ascospores are much smaller than in the type species. The writer has not seen the fungus in nature. Its association with definite cankers suggests a parasitic relationship. Though Hansbrough feels that the cankers may have been initiated by cicada injury, he states that the fungus is apparently parasitic on suppressed trees.

3. *CALICIOPSIS TILIAE* Arnaud, Ann. Epiphyt. 16: 262. 1930.

*Caliciopsis Ellisii* Sacc. var. *Tiliae* Arnaud, Ann. Ecole Nat. Agric. Montpellier, n.s. 12: 33. 1912.

TYPE: Arnaud states that his collections of this species were made from 1907 to 1913 at the Ecole Nationale d'Agriculture de Montpellier, in Hérault, France, all the material being taken from a canker on the trunk of a single tree of *Tilia sylvestris*. The two specimens cited by him were collected Feb. 18, 1907, and Sept. 17, 1913. A portion of the first of these, which presumably may be designated as the type, as well as material of a third collection made May 23, 1911, were very kindly sent to us by Arnaud, and have served as the basis for our studies (P).

Stromata initiated deep in the crevices of the bark, and erumpent there as minute, scattered cushions, each developing a small cluster of spermogonia and later one to several elongating ascocarps; spermogonium typically more slender than in other species, sub-fusoid,  $125\text{--}200 \times 300\ \mu$ , tapering above into a short beak and below into a more or less definite stalk; spermatia hyaline, allan-toid,  $3 \times 0.5\ \mu$ ; ascocarps pushing out through the crevices of the bark, as in *C. subcorticalis*, not protruding appreciably beyond its surface, visible in the crevices as erect, black spines, exceptionally variable both in length and lateral diameter, in some instances as



long as 2 mm., in others mature at less than half that extent, not infrequently having a forked tip or bearing short lateral branches; ascigerous locule subterminal to terminal; the apex in the latter case urceolate at maturity and very similar to that of *C. pinea*; ascospores ellipsoidal to subfusiform, yellowish-brown,  $7.5-10 \times 4-5 \mu$ , relatively large, exceeded in size in the known species of the genus only by those of *C. clavata*.

In spore characters the species resembles *C. calicioides*, but in the form of the ascocarp more closely approaches *C. subcorticalis*. The three species are known from so few collections that discovery of intergradation between them would not be wholly unexpected.

4. *CALICIOPSIS CALICIOIDES* (Ellis & Ev.) Fitzp. Mycologia 12: 220. 1920.

*Hypsotheca calicioides* Ellis & Ev. Jour. Myc. 1: 129. 1885.

*Caliciopsis Ellisii* Sacc. Syll. Fung. 8: 833. 1889.

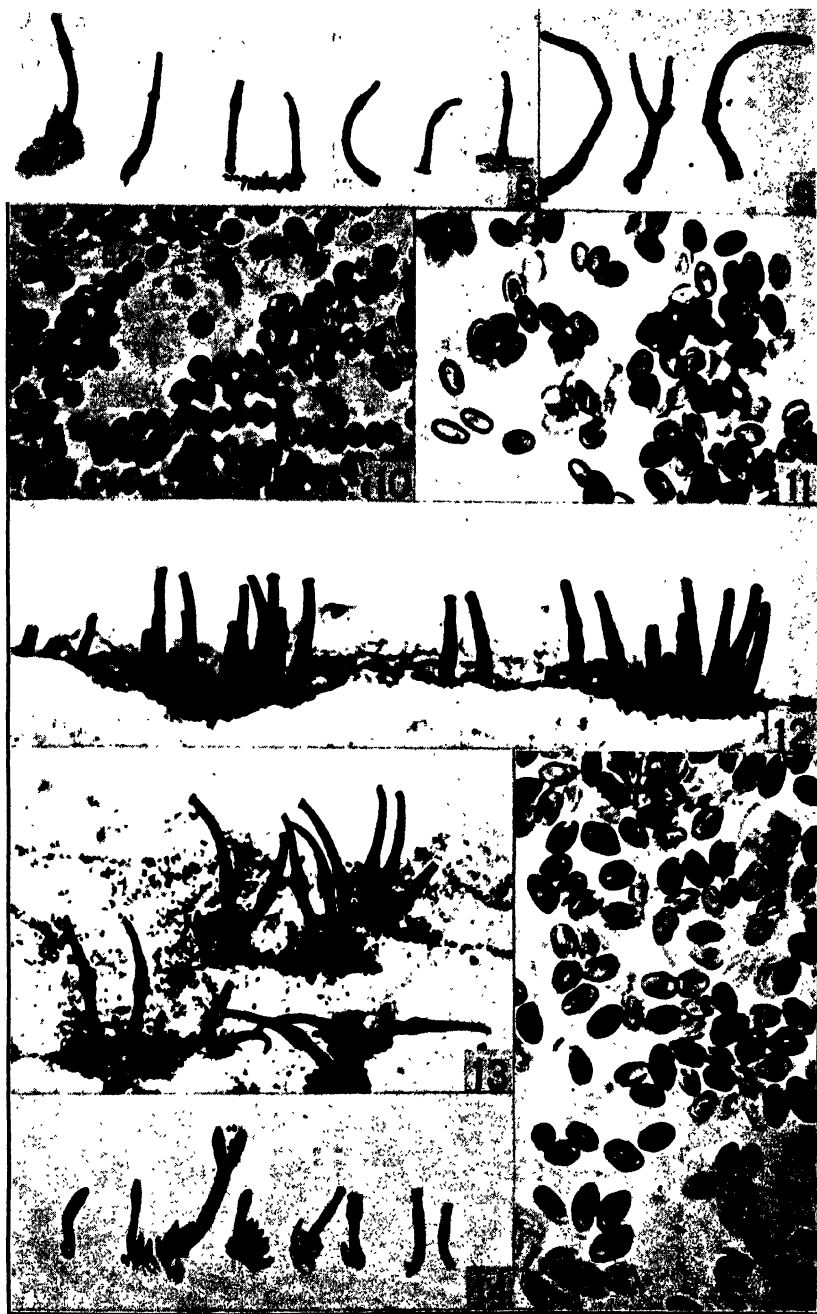
TYPE: A specimen in the herbarium of Ellis (N), labeled *Hypsotheca calicioides* E. & E., collected by Suksdorf (No. 256) in Washington Territory and sent to Ellis, Dec. 1883, by C. G. Sprague (F 1720). The original description of the species in the handwriting of Ellis is attached to this material and was clearly based on it.

OTHER MATERIAL EXAMINED: Ravenel, Fung. Carol. Exs. Fasc.

1. No. 83 (H, N); Overholts herbarium, No. 12079, col. E. H. Moss (No. 2114), Aug. 7, 1929, at Villeneuve, Alberta, on *Populus balsamifera* (F 2046); Ellis herbarium, No. 71 labeled "*Hypsotheca calicioides* (Fr.) var. *caespitosa* n. var.," col. March 1891 on decaying poplar log, at Lake Pend d'Oreille, Idaho (N, F 1719). We have provided photographs of the four<sup>18</sup> known collections to

<sup>18</sup> See also figures 35, 36 in the writer's earlier paper.

FIGS. 8-10. *Caliciopsis subcorticalis*. 8, 9, ascocarps removed from the bark, and arranged to show variation in size and shape,  $\times 11$ . 10, mature ascospores,  $\times 730$ . FIGS. 11-13. *C. calicioides*. 11, mature ascospores,  $\times 730$ . 12, ascocarps emergent from crevices in the bark, ex. Rav. Fung. Carol.,  $\times 11$ . 13, erumpent stromata bearing spermogonia and ascocarps, ex. Herb. Overholts,  $\times 11$ . FIGS. 14, 15. *C. Tiliae*. 14, ascocarps and spermogonia removed from the bark and arranged to show variation in size and shape,  $\times 11$ . 15, mature ascospores,  $\times 730$ .



FIGS. 8-15.

illustrate the variation in form of the ascocarp. The small number of specimens renders minor differences especially noticeable.

Stromata erumpent on bark of poplar, scattered or lying in concentric circles, occasionally confluent; the protruding surface covered with crowded spermogonia among which later a smaller number of ascocarps push out and elongate as black spines; spermogonium sessile to slightly stipitate, slender, approximately  $150\ \mu$  in lateral diameter, apically minutely umbilicate becoming perforate; spermatia slightly elongate,  $2.5\text{--}3\ \mu$  in length, hyaline, in mass yellowish; ascocarp reaching 2 mm. in length, composed of a stalk, a median or submedian enlargement containing the ascigerous locule, and a prominent beak; stalk  $100\text{--}170\ \mu$  in diameter, cylindrical, of varying length, somewhat broadened toward the base; ascigerous enlargement  $200\text{--}340\ \mu$  in median lateral diameter, tapering above and below to a total length of  $270\text{--}500\ \mu$ , sometimes collapsing laterally on drying; beak narrower than the stalk, with an average diameter of  $75\text{--}125\ \mu$  and a length approximately twice that of the ascigerous swelling, straight and rigid to slightly curved, tapering uniformly toward the apex, which in early stages is pointed and sometimes minutely umbilicate; terminal mass of extruded ascospores characteristically flattened; ascospores ellipsoidal to subfusiform,  $6\text{--}8 \times 3.5\text{--}5\ \mu$ , yellowish to light brown.

5. *CALICIOPSIS SUBCORTICALIS* (Cooke & Ellis) Fitzp. Mycologia 12: 223. 1920.

*Sphaeronema subcorticale* Cooke & Ellis, Grevillea 6: 83. 1878.

*Calicium ephemerum* Zwackh, Lichenen Heidelbergs p. 81. 1883.

*Hypsotheca subcorticalis* Ellis & Ev. Jour. Myc. 1: 129. 1885.

*Hypsotheca ephemera* Sacc. Syll. Fung. 10: 72. 1891.

*Caliciopsis ephemera* Rehm, Rab. Krypt.-Fl. 1<sup>a</sup>: 388. 1896.

TYPE: Fungi of New Jersey, No. 2743, in herbarium of M. C. Cooke ( $\kappa$ ), this being the original collection of *Sphaeronema subcorticale* Cooke & Ellis made by Ellis at Newfield, N. J., Sept. 16, 1877, on loosened bark on decaying limbs of oak lying on the ground; *co-type* material in herbarium of Ellis ( $\eta$ ).

OTHER MATERIAL EXAMINED: A collection made by Ellis at Newfield, March 1883, on oak bark ( $\eta$ ); another made by him in the same locality, April 1888, and distributed as Ellis & Ev. N. Am. Fungi 2123, which shows the fungus on bark of *Quercus coccinea*, especially on the surface of old galls believed by him to have been

caused by *Dichaena strumosa* (N, H); a third collection made at Wilmington, Delaware, by A. Commons (No. 1154), Dec. 1889, and labeled by him as collected "in crevices bark *Acer rubrum* L." The bark of this Delaware material is so badly decayed that our efforts to prove it to be *Quercus* have been unsuccessful. We have not seen a European collection of the species, and have not been able to verify the statement of Rehm that *Calicium ephemereum* Zwackh is identical. As the parasitic nature of the species and its host range are both in doubt, it is especially desirable that more material be collected. We have not seen the fungus in the fresh condition, and in no other species of the genus is our knowledge based on such fragmentary specimens.

Stroma usually hidden deep in the crevices of the bark and erumpent there, bearing a few spermogonia and one or two elongating ascigerous columns; the latter more variable in size and form than in other species, often curved or flexuous, not infrequently forked or bearing lateral branches, sometimes winding for a considerable distance through the crevices of the bark to reach the surface; the tips of the columns visible in the crevices at maturity and appearing as erect, black spines; columns exceptionally variable in lateral diameter, sometimes attaining 3 mm. in length, usually shorter, typically broadened at the base and tapering upward to a narrowed tip; ascigerous enlargement subterminal, surmounted by a definite beak; the enlargement 200–325  $\mu$  long, reaching 150  $\mu$  in lateral diameter, often little broader than the column below, sometimes laterally collapsed, asci (p. sp.) 12–15  $\times$  7–9  $\mu$ ; ascospores broadly ovoidal to globose, 4–5  $\mu$  in diam.; spermogonium approx. 100  $\mu$  in diam., apically perforate; spermatia 2.5–3.5  $\mu$  in length.

6. *Caliciopsis nigra* (Schrader ex Fries) comb. nov.

*Stilbum nigrum* Schrader, in Schleicher, *Plantae Cryptogamicae Helveticae*, No. 99, 1805; listed in Schleicher, *Catalogus Plantarum*, 3d. edit., p. 46, 1815, and 4th edit., p. 59, 1821; described in de Lamarck & De Candolle, *Flore Francaise*, 3d. edit. 2: 593. 1805; Fries, *Syst. Myc.* 3: 302, 342. 1832; not *Stilbum nigrum* Berk., in Hooker, *Engl. Flora* 5: 330. 1837.

*Ceratostoma juniperinum* Ellis & Ev. *Proc. Acad. Nat. Sci. Philadelphia*, p. 226. 1890.

*Ceratostoma stromaticum* Delacroix, Bull. Soc. Myc. France 7: 105. 1891.

*Corynelia juniperina* Arnaud, in Hariot, Bull. Soc. Path. Vég. France 2: 8. 1915.

*Lagenula nigra* Arnaud, Ann. Epiphyt. 16: 267. 1930.

TYPE: Schleicher, Plantae Cryptogamicae Helveticae No. 99, type of *Stilbum nigrum* Schrader ( $\kappa$ ), was examined by the writer and found to be the same as *Ceratostoma juniperinum* Ellis & Ev. and *C. stromaticum* Delacroix. This original collection was made in Switzerland on *Juniperus communis*. The writer is under obligation to Mr. E. W. Mason, who found the specimen in the herbarium at Kew and made it available for examination.

OTHER MATERIAL EXAMINED: type of *Ceratostoma juniperinum* Ellis & Ev., in Ellis herbarium ( $N$ ), col., Jan. 1889, by Rev. J. L. Zabriski, on *Juniperus virginiana*, on Long Island near New York City; D. Saccardo, Mycotheca Italica, No. 1297, col. autumn 1902, by P. Bacarini, at Fiesoli, Italy ( $N$ ); specimen labeled *Ceratostoma stromaticum* Delacroix, col. Apr. 1892, by Delacroix, on *J. Sabinae*, at Fontainbleu, France ( $H$ ); Jaap, Fungi Sel. Exsic. No. 682, col. O. Jaap, on *J. phoenicea*, Dalmatia, Yugoslavia ( $c$ ); specimen col. on *J. procera*, Nairobi, Kenya, West Africa, com. H. Wilkinson ( $\kappa$ ).

Stromata formed in the outer bark, erumpent chiefly in its crevices; ascocarps standing in these as crowded, black, blunt-tipped spines, relatively small as compared with those of other species of the genus, and more characteristically sessile; ascigerous enlargement usually basal in the column, or nearly so, but occasionally submedian (FIG. 18), considerably longer than wide,  $280-350 \times 170-240 \mu$ , at maturity often laterally collapsed, tapering above into a cylindrical beak,  $100-125 \mu$  in diam.; apex of beak bearing at maturity a rather broad, flat mass of extruded ascospores, and after dissemination of the spores appearing as a flattened funnel; the entire ascocarp shaped like a tiny decanter, as stressed by Arnaud in his characterization of the genus *Lagenula*; ascospores light brown to blackish brown, globose to ovoidal,  $4-5 \mu$  in diam., not uncommonly flattened or irregular.

This species is known to have been collected in eastern North America, East Africa, and various countries of Europe on the

bark of species of *Juniperus*, and is confined apparently to more or less definite galls. Whether it stimulates the formation of these has not been determined. The writer has not seen the species in nature. An organism reported by Neger<sup>14</sup> on similar galls on *Cupressus sempervirens* is perhaps the same. The galls on juniper are thought by Cavara<sup>15</sup> to be caused by a bacterial parasite, the *Caliciopsis* being regarded as secondary, but some other observers have disagreed with him.

The binomial, *Stilbum nigrum* Schrader, was first used by Schleicher on an herbarium label unaccompanied by descriptive matter. Though later he twice listed the name in publication, the first description was provided by De Candolle. Fries mentioned the species in *Systema Mycologicum* as *S. nigrum* and cited the De Candolle description. Though he did not describe the fungus, he understood its real nature, stating it to be near or identical with *Sporocybe calicioides*, now embraced in *Caliciopsis*. Effective publication of the specific name, under modern rules of nomenclature, dates from the action of Fries in attributing the species to Schrader, and in citing the description of De Candolle. Later Arnaud designated the species as the type of his new genus *Lagenula*.

7. *Caliciopsis clavata* (Lév.) comb. nov.

*Sphaeronema clavatum* Lév. Ann. Sci. Nat. III. 5: 257-280. 1846.

*Aposphaeria clavata* Jaczewski, Nouv. Mem. Soc. Imp. Nat. Moscou 15: 353. 1898.

*Corynelia clavata* Mont. in herb. Mus. Nat. Hist. Natur. Paris; not *C. clavata* (L.) Sacc., in Pirotta, Nuovo Giorn. Bot. Ital. 21: 313. 1889.

*Sorica clavata* Arnaud, Ann. Epiphyt. 16: 265-267. 1930.

TYPE: Collection made by Cl. Gay in Chili (Herbier du Chili austral envoyé par M. Gay: 3<sup>e</sup> envoi) on leaves and twigs of *Drymis chilensis* DC., deposited chiefly in the herbarium of G. Montagne (P). The species is known only from the original collection.

<sup>14</sup> Myc. Centralb. 2: 129. 1913.

<sup>15</sup> Bul. Soc. Bot. Ital. No. 8. 241. 1898.

Stroma erumpent through the ruptured epidermis of leaves and twigs, or emergent along the margin of wounds, bearing over the exposed surface in early stages a crowded group of spermogonia, among which cylindrical columns later protrude and elongate into considerably more prominent, clavate ascocarps; spermogonium  $250\text{--}400\ \mu$  in diam., usually stout, turbinate, and short-stipitate, with a minute, apical, perforate papilla; stalk of spermogonium sometimes abnormally elongated while the enlargement containing the spermatial cavity is of correspondingly reduced diameter, a slender clavate body resembling an immature ascocarp resulting (FIG. 21, upper right); ascocarp reaching a length of  $800\text{--}1100\ \mu$  and a diameter of  $275\ \mu$ , clavate until maturity, then with dehiscence assuming terminally an urceolate aspect; the tip finally with a flattened, brownish, pulverulent mass of extruding spores; ascospores subglobose to globose, brown,  $8\text{--}10\ \mu$  in diam., larger than in any other known species.

Léveillé, the first investigator to publish on the species, confused the slender, clavate, immature ascocarps with the abnormally long-stipitate spermogonia mentioned above. He considered both to be the beaks of pycnidia and described the fungus as *Sphaeronema clavatum* Lév. Later, Montagne discovered that some of the clavate structures contain asci, and labeled them *Corynelia clavata* Montagne. He did not publish this binomial and his use of it was probably unknown to Saccardo, who later applied it to a wholly different fungus on *Podocarpus*. Finally, Jaczewski found that fructifications of two sorts are present. Regarding the spermogonia as pycnidia, and noting that they are not beaked, he used the name *Aposphaeria clavata* Jaczewski to replace *Sphaeronema clavatum* Lév. For the ascocarp he suggested the name *Caliciopsis clavata*, but did not actually use the binomial. His statement that the apex of the ascocarp ruptures by a definite cleft is now known to be erroneous.

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FIGS. 16-19. *Caliciopsis nigra*. 16, galls on *Juniperus* bearing numerous ascocarps, especially in the crevices,  $\times 2$ . 17, portion of gall cut away to show the crowded ascocarps,  $\times 16$ . 18, a single ascocarp in longitudinal section showing a definite stalk,  $\times 50$ . 19, mature ascospores,  $\times 730$ . FIGS. 20-24. *C. clavata*. 20, crowded fruit-bodies, visible here only on the twig, but occurring on the leaf also,  $\times 2$ . 21, cluster of spermogonia, mostly short and turbinate, but four abnormal individuals at the upper right corner with long stalks and slightly swollen apices,  $\times 11$ . 22, clavate ascocarps of various ages arising among spermogonia,  $\times 11$ . 23, spermatia,  $\times 730$ . 24, asci with nearly mature ascospores,  $\times 730$ .



FIGS. 16-24.



8. *CALICIOPSIS THUJINA* (Ellis & Ev.) Mycologia 12: 265. 1920.  
*Hypsotheca thujina* Ellis & Ev. Jour. Myc. 1: 128. 1885.

TYPE: Specimen collected by J. B. Ellis (No. 1033) at Newfield, New Jersey, April 1880, on dying foliage of *Chamaecyparis thyoides* (N).

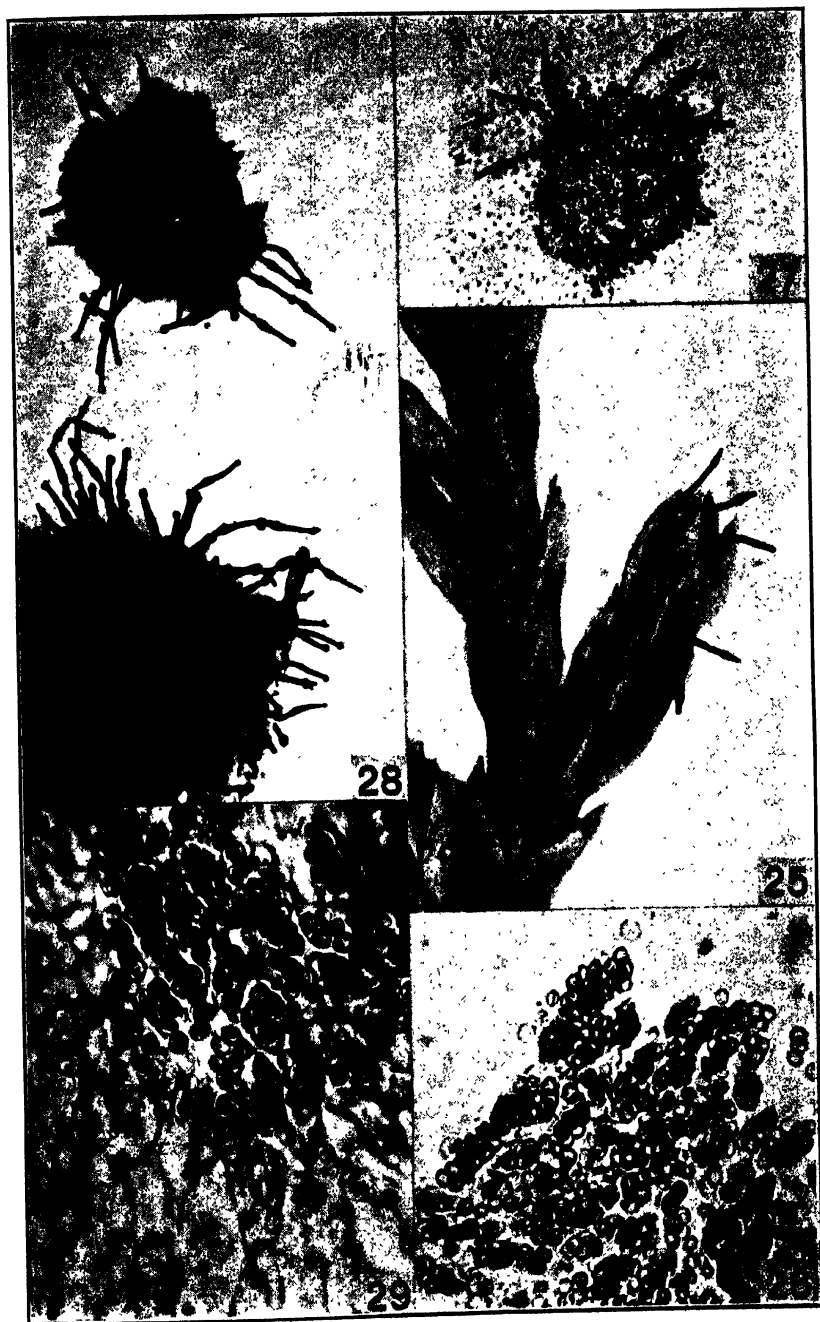
Ascocarps usually standing singly, occasionally in pairs, often accompanied at their bases by one to several spermogonia; spermogonium  $200\text{--}230 \times 150\text{--}170 \mu$ , apically perforate; spermatia hyaline, rod-like, straight or curved,  $2.5\text{--}3.5 \times 0.75 \mu$ ; ascocarp reaching a total length of 1 mm., consisting of a long stalk, a subapical enlargement containing the ascigerous cavity, and a terminal beak; enlargement ellipsoidal,  $150\text{--}175 \mu$  long, reaching  $110 \mu$  in diam., collapsed and flattened when dry; stalk cylindrical, straight or curved,  $600\text{--}750 \mu$  in length,  $60\text{--}75 \mu$  in diam., slightly broadened at the base; beak reaching  $110 \mu$  in length, of approximately the same diameter as the stalk, but tapering toward the tip; apex marked by an umbilicus which in dehiscence becomes a narrow funnel-shaped perforation through which the ascospores extrude forming a small, brown pulverulent knob; ascus (p. sp.)  $12\text{--}14 \times 5\text{--}6 \mu$ ; ascospores globose to subglobose, light brown,  $3\text{--}3.5 \mu$  in diam.

When the writer published his earlier treatment of the genus, he listed this species as doubtful. It had not then been possible to locate the type specimen in the herbarium of Ellis. As it seemed likely that it had been merely improperly filed, repeated search was made for it at the New York Botanical Garden over a period of fifteen years. Finally, in June 1934, it was discovered, accompanied by a detailed diagnosis in the handwriting of Ellis. The material is in good condition and embraces about forty ascocarps in various stages of development. The foregoing description and accompanying photographs were made from it.

9. *CALICIOPSIS MAXIMA* (Berk. & Curt.) Höhnelt, Sitz.-ber. Akad. Wiss. Wien 128: 84. 1919.

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FIGS. 25, 26. *Caliciopsis thujina*. 25, ascocarps arising from the imbricated leaves of *Chamaecyparis*,  $\times 11$ . 26, asci with mature ascospores,  $\times 730$ . FIGS. 27-29. *C. maxima*. 27, the primary series of unproliferated ascocarps protruding among the sporangia of the fruit-dot of *Polypodium*,  $\times 11$ . 28, older material showing linear series of ascocarps resulting from repeated proliferation,  $\times 11$ . 29, asci and mature ascospores,  $\times 730$ .



FIGS. 25-29.

*Capnodium maximum* Berk. & Curt. Jour. Linn. Soc. 10: 391. 1869.

*Sorica Dusenii* Giesenhagen, Ber. Deuts. Bot. Ges. 22: 191. 1904.

*Sorica maxima* Giesenhagen, Ber. Deuts. Bot. Ges. 22: 355. 1904.

*Capnodiella maxima* Sacc. Syll. Fung. 17: 621. 1905.

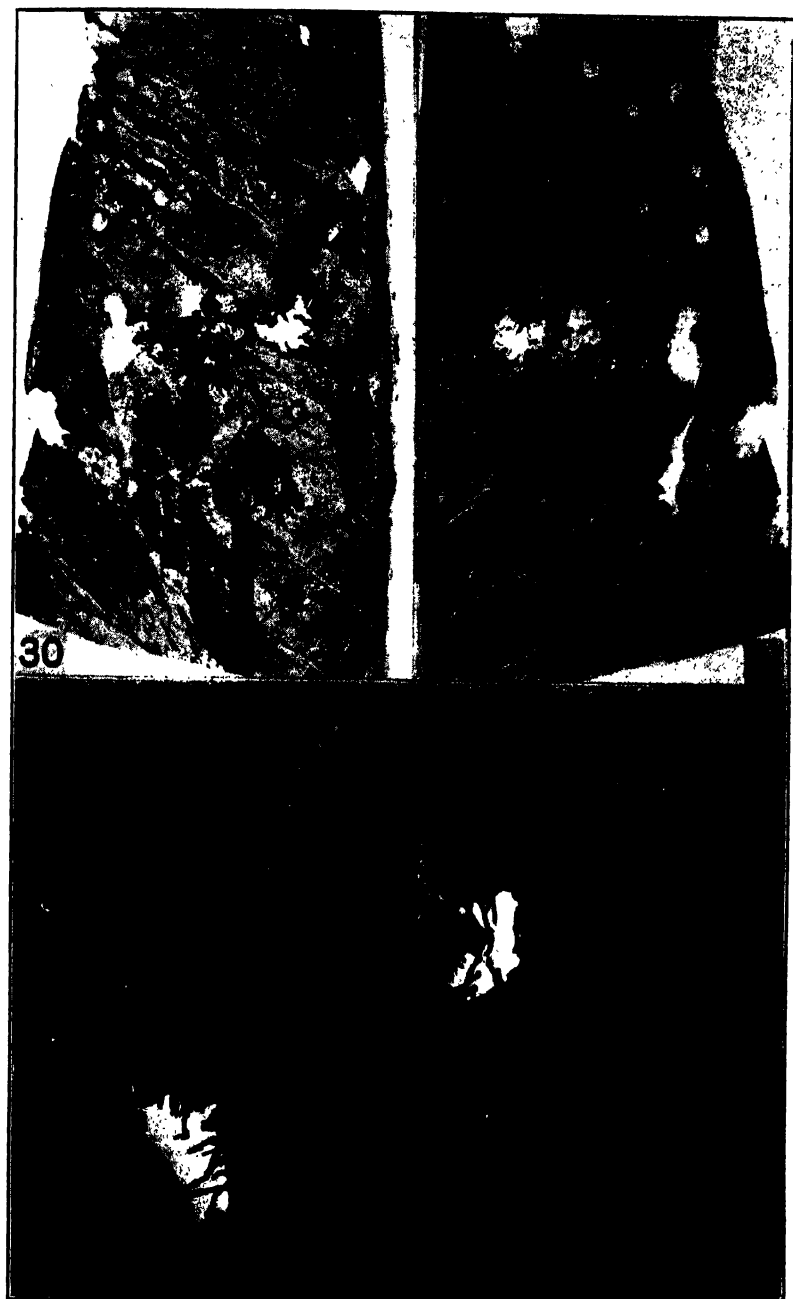
*Corynelia pteridicola* Stevens, Illinois Acad. Sci. Trans. 10: 179. 1917.

TYPE: No. 786 in herbarium of Berkeley ( $\kappa$ ). Collected in Cuba by Wright on *Polypodium*. Examined by the writer (F 1641).

OTHER MATERIAL EXAMINED: Fungi Cubenses Wrightiani No. 816 in Curtis herbarium (H) *co-type*; Porto Rican Fungi No. 3551, at University of Illinois, *type* of *Corynelia pteridicola*, col., Oct. 12, 1913, at Anasco, Porto Rico (F 1562); specimen No. 1021a, in herbarium Agric. Exp. Sta., Rio Piedras, Porto Rico, col. J. R. Johnston, Apr. 7, 1913, at La Romano, Dominican Republic (F 1528, c 12058); specimen col. by Sodiro, at Puente de Chimbo, Ecuador, deposited in Patouillard Herbarium (H, F 1640); Rehm Ascomyceten No. 1817, material col., Jan. 1909, by S. J. Rick at Theresiopolis, Serra Geral, Brazil (N, D, F 1638).

Mycelium parasitic in the fronds of ferns; stromata in some collections limited to the fruit-dots (sori of sporangia), showing no tendency to form in surrounding tissues, and ordinarily not even associated with discoloration of the opposite surface of the frond; in other collections occurring elsewhere in the frond only; when formed in the fruit-dot, hidden from view beneath the host sporangia, their presence unsuspected until the black, bristle-like columnar, ascigerous lobes push up and protrude; when developed elsewhere, visible early as minute, erumpent cushions, which increase in diameter and thickness after emergence and tend to become erumpent on the opposite leaf surface also; in older material, in many cases, found bordering definite holes and having in consequence a more or less completely annular form; ascigerous column,

FIGS. 30-32. *Caliciopsis maxima*. 30, upper surface of leaf of *Polypodium phyllitidis* showing perforations bordered by annular stromata bearing radiating, proliferating ascocamps,  $\times 2\frac{1}{2}$ . 31, lower surface of same leaf. 32, portion of same leaf,  $\times 11$ .



FIGS. 30-32.

long-stalked, prominently beaked, differing from that of all other known species in its tendency to undergo repeated apical proliferation, *i.e.* after dehiscence of the tip of the primary column and escape of the ascospores from its ascigerous enlargement, a second column formed by renewed growth of the hyphae at the margin of the funnel-shaped apex of the first, and in turn a third from the tip of the second, the process continuing until as many as five ascigerous locules have matured successively in linear series; less commonly a forked condition seen which results from proliferation of two columns from a single apex; the primary column usually longest, sometimes  $1500\ \mu$  in length; those formed later often not exceeding half that maximum; stalk long, slender, flexuous,  $35\text{--}50\ \mu$  thick, sometimes hairy with brown hyphae; enlargement containing the ascigerous locule ellipsoidal,  $125\text{--}150\ \mu$  in width and approximately  $250\ \mu$  in length, tapering equally above and below; beak,  $200\text{--}350\ \mu$  in length, in dehiscence apically perforate, forming a reddish-brown, pulverulent, terminal knob; asci (*p. sp.*)  $15\text{--}17 \times 10\ \mu$ ; ascospores typically globose, in some cases subglobose, possibly from shrinkage or mutual pressure, never definitely ellipsoidal, yellowish-brown,  $3\text{--}4\ \mu$  in diameter; spermatogonium sessile to short-stipitate, subglobose, papillate, often clothed in brown, hair-like hyphae; spermatia hyaline, unicellular, narrow-fusiform,  $11\text{--}24 \times 4\ \mu$ .

Parasitic on *Polypodium* (*Campyloneurum*) *crassifolium*, *P. phyllitidis*, *P. punctatum*, *P. Schomburghianum*, and probably other species. Known from Cuba, Porto Rico, San Domingo, Ecuador, Venezuela, and Brazil.

Material from seven collections of the species has been studied by the writer. In five of these the stromata occur exclusively in the sori. In the other two they are scattered over the leaf surface, sori being in fact absent. Though the general aspect of the fungus on the host in the two cases is thus dissimilar there is no correlated morphological difference to warrant recognition of two species. It may be of interest to record that in the type specimen of *Capnodium maximum* Berk. & Curt. the stromata are in the sori, while in the original specimens of *Corynelia pteridicola* Stevens they are not. Giesenhagen, who saw material of both sorts, suggests that occurrence of the fungus in the sori is common because the cell walls of that structure in the embryonic condition are thin and permit easy penetration, while the cuticle covering the epi-

dermal cells offers greater resistance. He states further that the stromata, formed outside the sori, border wounds caused by biting insects. Field observations led Stevens to believe that the holes in the leaf are due to the action of the fungus itself, not to insect injury. Though only herbarium material has been available to the writer, there seems to be evidence in it in support of the latter viewpoint.

10. **Caliciopsis Symploci** sp. nov.

TYPE: Material collected by T. Petch at Sita Eliya, Ceylon, April 1923, on *Symplocos obtusa* Wall., a dicotyledonous tree with glabrous, leathery leaves (F 2029). Another collection of somewhat younger material, taken from the same tree by Petch in March 1922 (F 2013), was also studied. Expression of appreciation is due the collector for placing the material at our disposal.

Columna stromatica magna et flexuosa; maximae sunt 2.75 mm; constant e stilo tenui cuius diametrus est  $100\ \mu$  fere, parte latiore plana et nonnunquam collapsa, ascigera ( $275 \times 150\ \mu$ ) et rostro magno et in aciem exeunte; ascospori sphaerici vel subsphaerici, brunneolis, diametri  $5.5\text{--}7\ \mu$ .

Mycelium parasitic in the leaves and young twigs; leaves markedly injured, as if by chewing insects; stromata formed on both leaves and twigs; on the leaf located chiefly along the petiole and midrib and at the margin of the blade rather than scattered over its surface, more rarely annular around a perforation as in the preceding species; the stromatic base giving rise to a few, inconspicuous, sessile spermogonia and a prominent, dense mass of extremely long, radiating, ascigerous columns; all of the latter thus far observed, relatively young, only a few dehiscent, and none observed undergoing proliferation; column at maturity often somewhat curved, reaching 2.75 mm. in length, composed of a long, slender stalk, approximately  $100\ \mu$  in diam., a flattened, often collapsed enlargement containing the ascigerous locule, and a tapering, pointed beak about half the length of the stalk; ascigerous enlargement attaining a length of  $275\ \mu$  and a width of  $150\ \mu$ ; ascus (p. sp.) clavate to saccate,  $22 \times 12\ \mu$ ; ascospores spherical or nearly so,  $5.5\text{--}7\ \mu$  in diam., light brown.

This species in the character of its spores and in its gross aspect on the host gives indication of being more closely related to *C.*



FIGS. 33-35.

*maxima* than any other. It is larger in its various measurements, however, and is parasitic on a host plant remote from the ferns. Had its ascigerous columns revealed proliferation comparable to that in *C. maxima*, the genus *Sorica* would perhaps have been retained for these two species.

## DOUBTFUL SPECIES

CAPNODIUM ARRHIZUM Pat. & Gaill. Bull. Soc. Myc. Fr. 4: 105. 1888.

*Lagenula arrhiza* Arnaud; Ann. Epiphyt. 16: 269. Pl. 7, figs. A-E. 1930.

TYPE: Champignons du Haut-Orénoque recullis en 1887 par A. Gaillard, No. 260. Found at San Fernando de Atabaya, Venezuela, on coriaceous, fallen leaves of an unidentified, probably dicotyledonous plant. Material deposited in the herbarium of the National Museum of Natural History in Paris. The species is known only from the type collection.

Stroma rupturing and shredding the leaf surface and causing the formation there of a prominent, pulvinate excrescence; ascocarps emergent individually from the shredded covering layer and undergoing elongation without exposure of the stromatic base buried in the host, tending to radiate as if from a common center and at maturity lying almost horizontal on the surface of the leaf; mature ascocarp black, filiform, extremely slender, straight or slightly flexuous, measuring 1-1.5 mm. in length, composed of an essentially basal ascigerous enlargement and a long hair-like beak; enlargement 100-125  $\mu$  in lateral diameter and approximately 225  $\mu$  in length, tapering above into the beak; asci clavate on long, slender stalks, apparently 8-spored; ascospores seen only in the very immature condition; paraphyses lacking; spermogonia not observed.

The above diagnosis is based on the writer's own study of a portion of the original collection recently made available to him. As broken ascocarps spoiled the specimen for photography, no illustrations of the species are provided here. The drawings of

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FIGS. 33-35. *Caliciopsis Symploci*. 33, ascocarps radiating from stromata on twigs and leaves of *Symplocos obtusa*,  $\times 2$ . 34, single group of ascocarps on enlarged portion of petiole,  $\times 11$ . 35, asci and mature ascospores,  $\times 730$ .



Arnaud picture the various structures correctly and adequately. Though the form of the ascocarp and the appearance of the ascospore-initials indicate that the species belongs in or near *Caliciopsis*, its inclusion is only tentative.

DEPARTMENT OF PLANT PATHOLOGY,  
CORNELL UNIVERSITY,  
ITHACA, NEW YORK

## CONTRIBUTIONS TO THE MYCOFLORA OF BERMUDA—III

F. J. SEAVER AND J. M. WATERSTON

(WITH 3 FIGURES)

Our fourth visit to Bermuda covered almost exactly the same period as the previous one (Nov. 24–Dec. 12), and while many of the same forms were re-collected, there were a number of marked differences. In 1938 *Clavaria vermiculata* Mich. was found to be quite common and widely distributed in the Islands. It was especially interesting because it was the first *Clavaria* to have been reported from Bermuda. The senior writer remarked at the time that he was certain this fungus had not occurred there during his previous visits, although these were made at about the same season of the year. Notwithstanding the fact that it was found to be rather common in 1938, not a single specimen was observed in 1940, although the same ground was covered. This illustrates again the sporadic habits of many of the fungi, and emphasizes the necessity of revisiting a region if one is to get a thorough knowledge of its fungous flora.

In contrast with the above, we should mention the rare puffball *Lycogalopsis Solmsii* E. Fischer. Two or three specimens of this were collected in 1938, in one of the sinks in the Walsingham region, and because of its unusual occurrence in the western hemisphere it attracted special attention. In 1940 the same sink was thoroughly searched and the fungus found to be well established, and a goodly amount of material obtained.

This would indicate that some fungi are rather constant in their occurrence from year to year, while others apparently occur spasmodically. While the nature of the substratum has much to do in determining the distribution of the fungi, other factors must enter into the problem, for in no other way can we account for the fact that certain forms occurring on humus may be found year after year in the same locality, while others like the *Clavaria* will be

found only once in several years. Of course, those species which occur on decaying plant materials are likely to be constant in their appearance, such as *Pithya Cupressi* and *Pseudopithyella minuscula* on *Juniperus*; *Nectria Lantanac* on *Lantana*; *Calonectria Umbelliferarum* on *Foeniculum*; and *Ophionectria cylindrothecia* on the native palm *Sabal bermudana*. The strictly parasitic species are also likely to be constant.

During our 1940 visit a number of interesting observations were made on species previously reported, while a goodly number of additions were obtained. Also, a few are here recorded as new to science. The new records for the Islands are indicated with an asterisk. Where not otherwise indicated, collection numbers in italics are our own.

#### DISCOMYCETES

##### ASCOPHANUS BERMUDENSIS Seaver.

This species has recently been reported from Florida by Erdman West (*Mycologia* 33: 38. 1941).

##### PSEUDOPITHYELLA MINUSCULA (Boud. & Torrend) Seaver.

This species, formerly known only from Portugal and Bermuda, has recently been reported from the Yosemite Valley, California, on incense cedar (*Libocedrus decurrens* Torr.). The senior writer has had the privilege of examining Californian material and finds it identical with the Bermuda collections.

##### \*CENANGELLA DEFORMATA Peck (FIG. 2).

Two collections of this species were made on the bark of cedar, *Juniperus bermudiana*. It was previously known only from New York, Montana and Wyoming. Bermuda material, 337, agrees very well with other material examined.

##### HELOTIUM ATROSUBICULATUM Seaver & Waterston (FIG. 1, lower).

This fungus was re-collected in 1940 on dead leaves of *Archontophoenix* in the same general region as in 1938. Dr. Lawrence White reports that this species was twice collected by Dr. David Linder in British Guiana and Trinidad in 1923 on the same host.

**Helotium Conocarpi** sp. nov. (FIG. 1, upper).

Apothecia gregarious at first subglobose and sessile, becoming expanded and short stipitate, reaching an extreme diameter of 3 mm., the hymenium usually remaining concave, the margin even or nearly so; hymenium with a delicate lilac tint, externally nearly the same above, darker toward the base; stem scarcely exceeding 1 mm. in length; asci clavate, reaching a length of 50–60  $\mu$  and a diameter of 6  $\mu$ , 8-spored; spores ellipsoid, hyaline  $4 \times 10 \mu$ ; paraphyses filiform, scarcely enlarged above, about 2  $\mu$  in diameter.

Apotheciis gregariis primo subglobosis, sessilibus, dein expansis, brevi stipitatis, 3 mm. diam.; hymenium concavo, lilacino; stipitibus 1 mm. altis; ascis clavatis  $6 \times 50\text{--}60 \mu$ , 8-sporis; sporis, ellipsoideis, hyalinis  $4 \times 10 \mu$ ; paraphysibus, filiformibus, 2  $\mu$  diam.

On dead leaves of *Conocarpus erectus* L., 375, 425.

This fungus was found to be rather abundant on the fallen leaves of its host. However, the cups are often so small, and even when expanded so nearly like the substratum in color, that very close search is necessary to find them.

**SCLEROTINIA SCLEROTIORUM** (Lib.) de Bary.

This species attacks over forty different hosts in Bermuda. It was found locally for the first time on a monocotyledonous host, the Dwarf Cavendish banana, *Musa Cavendishii* Lamb., by T. A. Russell, causing a rot of the fruit and sterile flowers. This host record has only previously been recorded by I. Reichert and E. Hellinger from Palestine.

\***RUTSTROEMIA NERII** Whetzel & White, Lloydia 4: 226. 1941.

This species reported on fallen, decaying leaves of *Nerium Oleander* L. was based on material collected by the senior writer and H. H. Whetzel on a joint exploring expedition to the islands during the winter of 1926.

**STICTIS COCCOLOBII** Seaver & Waterston.

This species was described in 1940 from material collected in 1938. During a visit to Florida the last week in February, 1942, a second collection was made on *Coccolobis* leaves in Bay Front Park, Miami, it will probably be found to be widely distributed.



FIG. 1. Upper, *Helotium Conocarpi*; lower, *Helotium atrosubiculatum*.

**STICTIS CONOCARPI** Seaver & Waterston.

This species, previously known only from a scant collection made in 1926, was re-collected by the junior author in Devonshire, March 25, 1942. Several fine specimens were obtained.

## PYRENOMYCETES

**Amphisphaeria fusispora** sp. nov. (FIG. 3, lower).

Perithecia widely scattered, appearing flattened with their bases nestling in the substratum, rounded or slightly compressed, black, 200–250  $\mu$  in diameter, the ostiole indistinct; asci clavate, reaching a length of 125–150  $\mu$  and a diameter of 20–30  $\mu$ , 8-spored; spores irregularly 2-seriate, fusiform 1-septate, slightly constricted in the middle,  $12 \times 60\text{--}70 \mu$ , at first hyaline becoming rather dark brown, containing several large oil drops.

Peritheciis sparsis, magnis, depressis, atris 200–250  $\mu$  diam.; ascis clavatis, 20–30  $\times$  125–150  $\mu$ ; 8-sporis; sporis distichis, fusiformibus, hyalinis dein fuscis, 1-septatis, medio leniter constrictis  $12 \times 60\text{--}70 \mu$ .

On bark of cedar, *Juniperus bermudiana* 370.

The species is distinguished by its unusually large fusiform spores.

**\*ANTHOSTOMELLA NIGROANNULATA** (Berk. & Curt.) Sacc.

This species was described from material collected in Cuba and is probably co-extensive with its host, *Yucca aloifolia* L. Excellent material from Bermuda is a noteworthy extension of range, 364.

**\*BOTRYOSPHAERIA RIBIS** (Tode ex Fries) Grossenbacher & Duggar.

This species was found on dead aerial portions of cuttings of cassava, *Manihot utilissima* Pohl., which appears to be a new host record. Ascospores measured  $12.5\text{--}24.0 \times 6.9\text{--}10 \mu$  and averaged  $18.8 \times 8.4 \mu$ . Single ascospore cultures gave rise to a *Dothiorella* stage which Dr. N. E. Stevens kindly examined and pronounced typical of the species. Inoculation experiments proved the fungus to be only weakly parasitic.

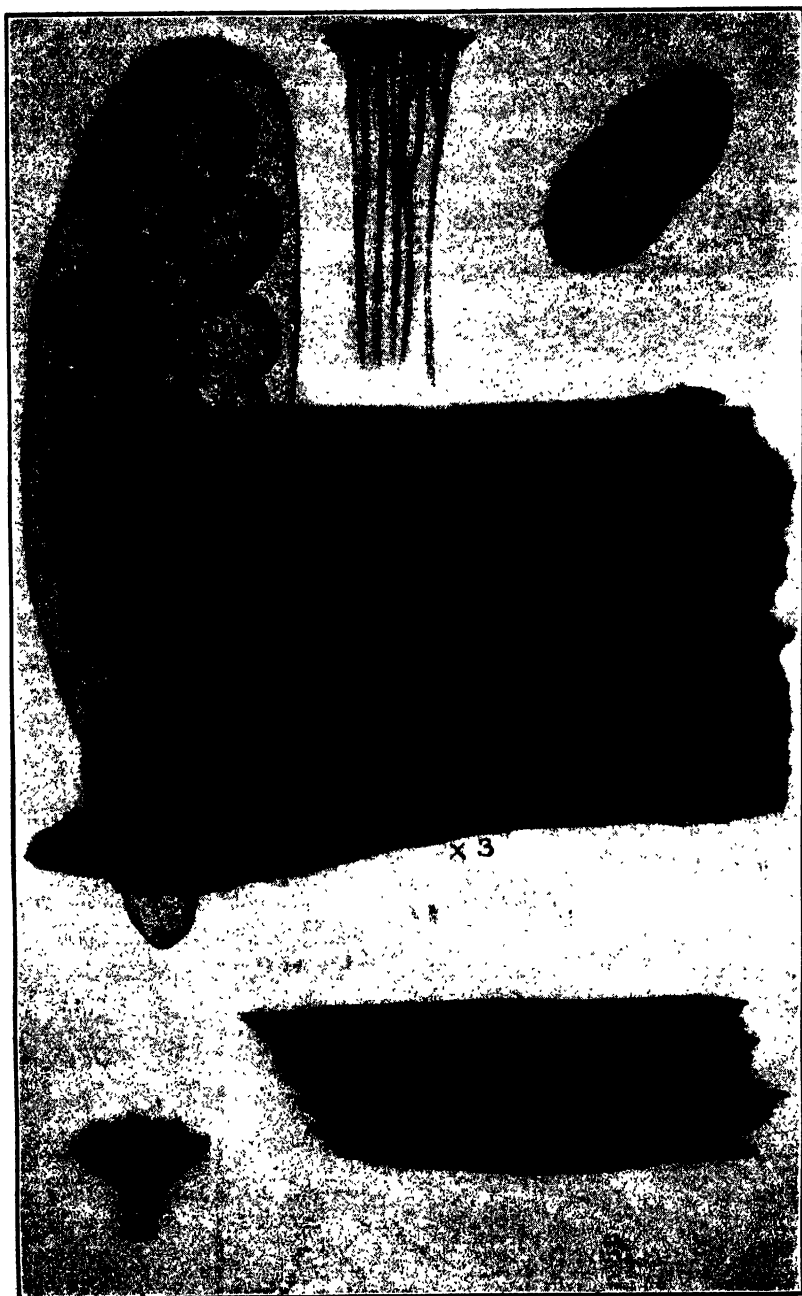


FIG. 2. *Cenangella deformata*.

\**DIDYMOSPHAERIA ANDROPOGONIS* Ellis & Langlois (FIG. 3, upper).

Material collected in Bermuda on *Andropogon Schoenanthus* L., has been compared with type material and found to agree perfectly. So far as can be learned, this species was previously known only from the type collection obtained in St. Martinsville, Louisiana, and described more than fifty years ago (Proc. Acad. Sci. Phila. 1890: 235). The spores are delicately striated, a character which was not mentioned in the original description, 315.

*ENDOTHIA COCCOLOBII* Viz.

This species was described from material collected in Bermuda by H. H. Whetzel in 1921–22 (Mycologia 15: 115. 1923). The fungus was originally reported on fallen green fruits of *Coccolobis uvifera* (L.) Jacq. The writers, during our explorations in 1940, noted a bright orange *Endothia*-like growth on the branches and trunks of the above host. Examination of type material has convinced us that this is *Endothia Coccolobii* and that it is probably not restricted to the seeds, as at first thought, 326.

\**NEUROSPORA SITOPHILA* (Mont.) Shear & Dodge.

The conidial stage was collected on old paper, 314. The material was identified by Dr. B. O. Dodge and the perfect stage produced by him in culture.

*PENZIGIA BERMUDENSIS* J. H. Miller.

The species first collected in 1938 was re-collected in 1940 and found to be very abundant on dead twigs of fiddlewood, *Citharexylum spinosum* L., on which it was originally collected, although this was not identified when the description was published, 371.

BASIDIOMYCETES

*AGARICUS CAMPESTRIS* L.

Artificial culture of a white strain of this species imported from the United States of America was attempted on an amateur scale at the Agricultural Station on a compost composed of horse manure



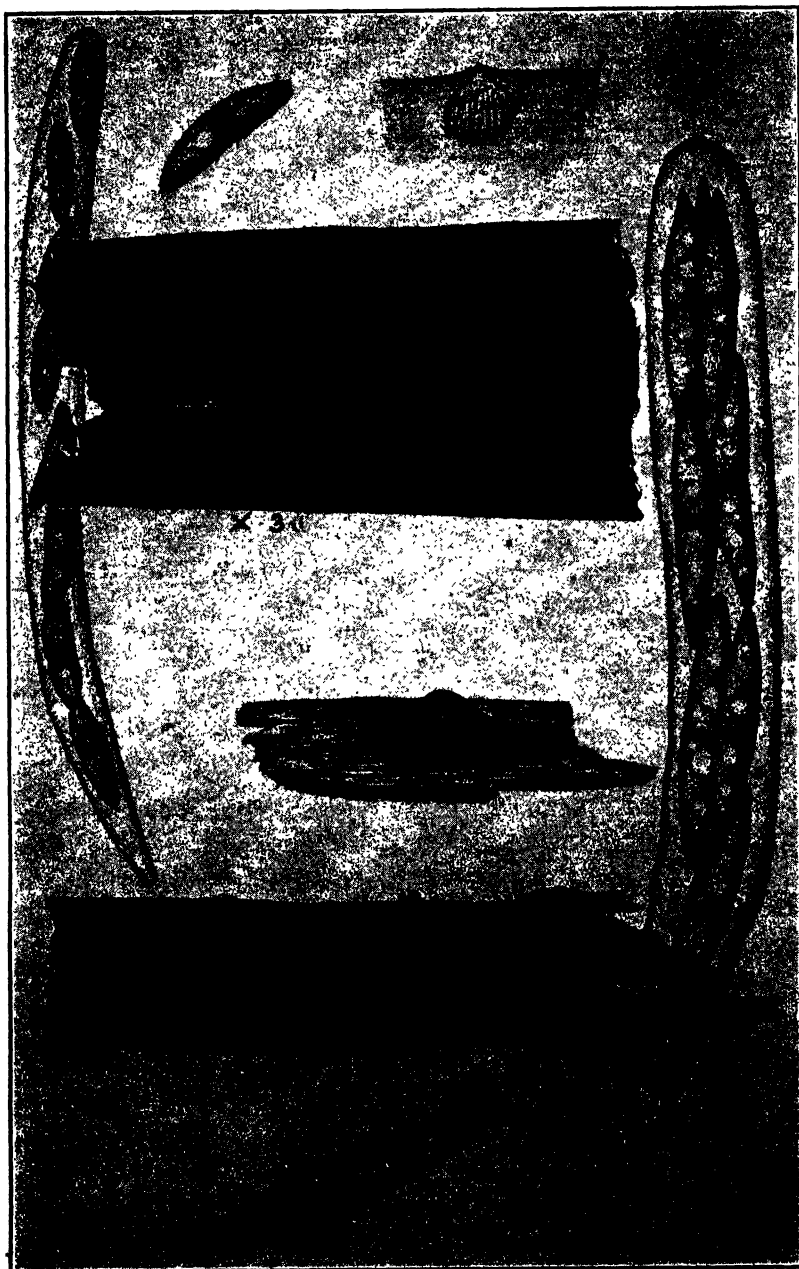


FIG. 3. Upper, *Didymosphaeria Andropogonis*; lower, *Amphisphaeria fusispora*.

from grain-fed animals and "Pond Shags," *Typha angustifolia* L., which is locally used as a substitute for straw bedding. A yield of nearly one pound per square foot was obtained during the winter months.

**POLYPORUS GRAMINICOLA** Murrill.

This interesting species was found for the first time in the absence of a monocotyledonous host, underneath a hedge of *Acalypha Wilkesiana* Muell. Arg. at the Agricultural Station. The sporophore measuring  $8 \times 5\frac{1}{2}$  inches was attached to a rotten stump.

**\*UROMYCES BERMUDIANUS** Cummins.

This species was recently described from material collected on *Cyperus paniculatus* Rottb. by the writers on November 28, 1940, 351. (See Bull. Torrey Club 68: 470. f. 1. for detailed discussion and illustrations.)

The following basidiomycetes have been identified by Miss E. M. Wakefield: *\*Auricularia polytricha* (Mont.) Sacc. on an old stump of fiddlewood, *Citharexylum spinosum* L.; *\*Dacdalea Berkeleyi* Sacc., causing extensive rotting to an old fence rail; *\*Odontia arguta* (Fr.) Quél., on fallen logs of *Casuarina equisetifolia* L.; *\*Peniophora cinerea* (Pers.) Cooke on *Acalypha Wilkesiana* Muell. Arg.; and *\*Polyporus gilvus* (Schw.) Fries on fallen logs of *Casuarina equisetifolia* L., and *Juniperus bermudiana* L.

FUNGI IMPERFECTI

**\*CERCOSPORA GUANICENSIS** Young.

This species, originally described from material collected in Porto Rico on *Guilandina crista* (L.) Small, was found in abundance on the same host in Bermuda, 321.

**\*DIPLODIA THEOBROMAE** (Pat.) Nowell.

This species was found responsible for considerable wastage to tubers of cassava, *Manihot utilissima* Pohl. following stormy weather. The fungus behaved as a wound parasite, entering

through cracks caused by wind damage. Pycnidia were found on dead aerial portions of the stems associated with perithecia of *Botryosphaeria Ribis*. Cultural studies, however, revealed no connection between these two fungi.

\**OZONIUM AURICOMUM* Link.

This sterile mycelium was found on dead stems of *Osmunda cinnamomea* L. It occurs on various substrata in North America and the West Indies, as well as in Europe, 330.

\**PESTALOTIA MICHENERI* Guba.

On the inflorescence of *Araucaria excelsa* R. Br. Found abundantly on dead inflorescence of the above host, 320.

\**SEPTORIA ACICOLA* Thüm.

On needles of *Pinus palustris* Mill. N. L. Britton in his Flora of Bermuda reports a single tree of this species at Inglewood. This is probably the only tree of the species in the Islands, and the fungus was found on the needles of this tree, 384.

*XENOSPORELLA BERKELEYI* (Curtis) Linder.

This species has been determined by Dr. David Linder from material collected on the dead poles of *Agave* associated with *Patellaria atrata*, 332b. The species is closely related to *Helicoma larvale* Morgan, which had been previously reported from Bermuda by us on *Sabal*. It seems likely that all the collections filed under the name of *Helicoma larvale* Morgan are *Xenosporaella Berkeleyi*. This should not be confused with *Helicomycetes roseus* Link which occurs on the same host *Sabal* and is always associated with *Ophionectria cylindrothecia* Seaver.

NEW YORK BOTANICAL GARDEN  
AND  
DEPT. OF AGRICULTURE,  
PAGET EAST, BERMUDA.

## CILIOSPORA ALBIDA

H. H. WHETZEL

(WITH 1 FIGURE)

On December 2, 1941, leaves of *Prunus serotina* invaded by *Rutstroemia pruni-serotinae* Whet. & White were placed on moist sand in a large moist chamber to observe the development of apothecia. These leaves, which had fallen during the autumn of 1941, showed the net-like black stromata of the *Rutstroemia* already developed. Apothecia began to appear in about two weeks.

On certain of the leaves in one of the moist chambers there were observed at the same time scattered minute white gelatinous masses which aroused my curiosity. A mount of the gelatinous ooze disclosed under the low power of the microscope innumerable large hyaline cylindrical spores with rounded ends, each spore adorned with long, slender, spine-like, hyaline appendages (FIG. 1). The spores are one-celled, and shaped strikingly like long medicine capsules. The mature spores are unusually uniform in size measuring  $35 \times 10 \mu$ . The appendages are borne typically in pairs about each end of the spore, usually two pairs at each end, with occasional spores bearing an extra pair or two along the side. In the typically 8-appendaged spores, one pair, at what appears to be the tip end of the spore is longer and larger than the other pairs. The appendages of the longer pair are approximately the length of the spore, those of the other pairs being somewhat shorter and more slender at the base. Some mature spores have fewer than 8 appendages, some probably broken off, but rarely more than 8. In many cases a bead-like drop of a hyaline gelatinous material is to be observed surrounding each appendage at or toward its base (FIG. 1). The walls of the spore are thin, the contents very granular.

Crushed mounts of the fruit bodies disclose that the spores are produced singly on the ends of very slender long hyaline conidio-

phores, which arise from the circular embedded base of the fruit body. The young spores are at first without appendages.

The fruit body about 1 mm. in diameter arises within the leaf tissues and breaking through the epidermis, forms a short columnar mass not more than 2 mm. tall. It appears to consist of a rather thick walled cylinder, the wall composed of interwoven very slender

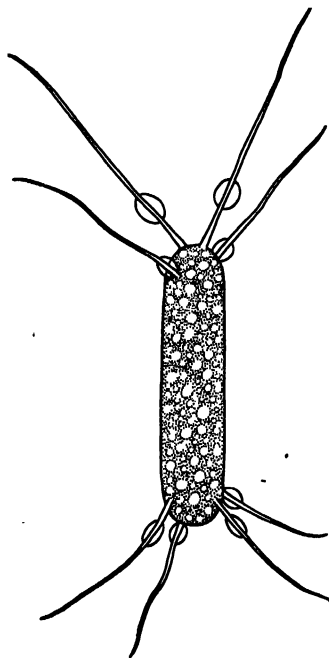


FIG. 1. A typical spore of *Ciliostora albida*. Drawn from mature living spore. The oval bodies on the appendages are drops of mucilaginous material. Approximately  $\times 1000$ . Drawing by Regina S. Brinkerhoff.

hyphae held together by a gelatinous matrix. The spores which are produced in immense numbers are likewise embedded in a mucilaginous material, which causes them to ooze slowly from the ruptured apex of the fruit body. They soon separate and diffuse rapidly into the surrounding water, occasionally darting forth as if propelled with some force. This pearly white mass of spores gives the dominant white color to the freshly sporulating fruit body. The low wall of the fruit body is, however, of a reddish

brown color. On drying the gelatinous fruit body appears as a minute dried drop of glue of a translucent amber color.

Repeated attempts to germinate the spores in dilution plates of acidified potato dextrose agar failed, so that it has not been obtained in pure culture. In hanging drops of water in which bits of cherry leaf were placed along with the conidia, germination of many spores was observed. The germ tubes appear to develop from the appendages which enlarge slightly and branching form a thallus of very slender spreading hyphae. The young unappendaged spores were also observed to germinate by very slender branching germ tubes.

#### IDENTITY OF THE FUNGUS

Dr. David H. Linder, to whom fresh specimens were sent, suggested that this fungus appears to be *Dilophospora albida* Mass. & Crossl.

A comparison of the characters of our fungus with the original description of *D. albida* discloses no striking differences. *D. albida* as originally described from dead stems of *Epilobium hirsutum* in England is said to have 3–6 appendages to each spore, the spores  $30\text{--}40 \times 7\text{--}8 \mu$ , sometimes slightly curved. The spores of our fungus while corresponding fairly well as to size are rarely curved and when mature bear typically 8 appendages clearly paired.

Grove (1937: 117–118) redescribed *D. albida* transferring it to the genus *Ciliospora* of Zimmermann (1902: 217). Grove's description appears to be based upon a reëxamination of the Needham collection of August 1890, the dried specimen upon which Massee and Crossland based their original description of the species. This may account for the somewhat smaller spore measurements.

A comparison of our specimen with Grove's revised description leaves little doubt in my mind as to the identity of my fungus with that of Massee and Crossland.<sup>1</sup>

<sup>1</sup> This conclusion is supported by Dr. E. W. Mason of the Imperial Mycological Institute, Kew, England, who has kindly made a critical comparison of a specimen from my collection with the type of *C. albida* (Mass. & Crossl.) Grove. (Letter of May 28, 1942 received after this paper had gone to press.)

The differences appear to be as follows:

| <i>Ciliospora albida</i>                  | Whetzel's specimen                                     |
|---|--|
| 1. Spores oblong fusoid.                  | 1. Spores oblong cylindrical.                          |
| 2. Meas. $28-40 \times 6-8 \mu$ .         | 2. Meas. $35 \times 10 \mu$ .                          |
| 3. Spores faintly colored.                | 3. Spores hyaline.                                     |
| 4. Appendages 0-5 per spore. <sup>2</sup> | 4. Appendages 8, in pairs, occasionally more or fewer. |

Otherwise Grove's revised description tallies well with the characters of the fruit body, etc. of my fungus. The differences pointed out above may not be significant and due to the fact that the original as well as Grove's revised description is based on long dried material while my observations have been made entirely on the fresh growing fungus.

The question as to the genus to which my fungus should be referred is an interesting one. The genus *DILOPHOSPORA* was established by Desmaziere (1840: 6-7) for the pathogenic fungus *D. graminis* Desm. occurring on numerous grasses in Europe and originally described by Fries (1828: 91) under the name *Sphaeria Alopecuri*. Later Bessey (1906) called attention to the fact that Fries had later transferred the species to Desmaziere's genus under the name *Dilophospora Alopecuri* Fries which name has since been generally accepted for the fungus (Grove 1935: 449). The most complete and extensive paper on this fungus and its synergistic relationship to *Tylenchus Tritici*, the cause of nematode disease of wheat, rye, etc., is that by Atanasoff (1925).

An examination of specimens and descriptions of *D. Alopecuri* in comparison with Grove's (1935) description of *Ciliospora albida* should convince any one that the two species are generically quite distinct and unrelated.

Zimmermann (1902) established the genus *CILIOSPORA* for a species of fungus occurring on rotting pods of Cacao in Buitenzorg, Java, to which he gave the name *C. gelatinosa*. It is at once obvious on comparing the description of *C. albida* as detailed by Grove, with that of *C. gelatinosa*, that the two species are co-generic, but probably distinct. Although Grove makes no comment

<sup>2</sup> According to Groves; Massee and Crossland give the number as 3-6.

on his transfer of *Dilophospora albida* Mass. & Crossl. to Zimmermann's genus *Ciliospora* it is obvious that he recognized the fact that it is not a *Dilophospora* but is clearly co-generic with *Ciliospora*.

As far as I have been able to discover, my collection of *Ciliospora albida* on fallen leaves of *Prunus serotina* is the first record of this species in America and apparently the second known collection in the world. It seems therefore worth recording as a very interesting little fungus. It would be of interest to know what the perfect stage of this conidial form is. Failure to get it in pure culture has been a disappointment but I shall continue to look for the species in the future hoping to find some ascogenous form of which it is most likely the conidial stage.

Whether of any significance, it should be recorded that on leaves in which this imperfect occurred, few or no apothecia of the *Rutstroemia* developed, while from nearby leaves apothecia arose in numbers. That apothecial development may have been inhibited by pathogenic action of the *Ciliospora* is an interesting speculation.

The specimen of *Ciliospora albida* on which this note is based, was developed in a moist chamber in the laboratories of the Department of Plant Pathology at Cornell University on leaves of *Prunus serotina* collected December 2, 1941, by H. H. Whetzel and John Niederhauser in the Lloyd Preserve at McLean near Ithaca, New York. The specimen is deposited in the herbarium, Dept. Plant Path., Cornell Univ. under the number 29792. Duplicate material is deposited in the Farlow Herbarium, Harvard University.

During February 1940, there appeared on dead petioles of a palm, *Achrontophoenix Alexandrac*,<sup>3</sup> in a moist chamber in my laboratory the fruit bodies of a conidial form bearing long appendaged spores, associated with the stroma of *Helotium atrosubiculatum* Seaver & Waterston (1940). The fruit bodies were minute gelatinous cushions essentially like those of *C. albida*. Thinking this conidial form might be a stage in the life history of *H. atrosubiculatum*, dilution plates of the conidia were made and the

<sup>3</sup> The material had been sent me by J. M. Waterston of the Bermuda Experiment Station.



fungus obtained in pure culture. Some preliminary sketches and spore measurements were made by Dr. W. L. White. Comparison of the conidial cultures with those of ascospore isolates of *H. atrosubiculatum* soon satisfied me that the two fungi were not genetically connected.

The appendaged conidia grew readily in non-acid potato dextrose agar but refused to grow on acidified agar. The culture formed a limited white mycelial mat with masses of naked sporodochia of a pale pinkish yellow color. Typical appendaged conidia were produced in great abundance. No attempt was made at the time to identify the interesting little imperfect. Since it was clearly not the conidial stage of *H. atrosubiculatum* nothing further was done with it.

When *C. albida* turned up last December, Dr. White reminded me of the appendaged spore form we had previously found on the palm leaves from Bermuda. Unfortunately the cultures of that fungus are now dead. Attempts by both myself and Dr. White to locate fruit bodies on the dried specimens of the palm petioles which had been preserved have proven fruitless. White's sketches and spore measurements, however, correspond more closely with those of *C. gelatinosa* as given by Zimmermann (1902); White's measurements are  $26-33 \times 5.6-8 \mu$ , Zimmermann's  $15-30 \times 5-6 \mu$ . Since the Bermuda fungus comes from a tropical habitat the limited data now available would seem to suggest its identity with *C. gelatinosa* from Java rather than with *C. albida*. Further collections and studies may even prove these two species to be one and the same.

CORNELL UNIV.,  
ITHACA, N. Y.

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# STUDIES IN THE GASTEROMYCETES VI

W. H. LONG

Through the kindness of Mr. John A. Stevenson, I have been able to examine the types of *Bovistoides simplex*, *Bovistoides Torrendii* and *Phellorina macrospora*. The following data give the results of my studies of these three *Gasteromycetes*.

## THE GENUS BOVISTOIDES

*Bovistoides simplex* Lloyd. This species was based on a single plant collected in the Transvaal, South Africa, by Miss A. V. Duthie. A description of the genus and species is given by Lloyd in his *Mycological Writings* 6: 883 with figures 1517 and 1518. Figure 1517 shows the plant natural size, while figure 1518 is a photomicrograph of the spores and capillitium, magnification not stated but probably about 100 diameters.

The genus *Bovistoides* is based entirely on the character of the capillitium, which is described as having "short, simple (rarely branched) threads running into points." The type of the genus is *Bovistoides simplex*. The type specimen (Lloyd's Cat. No. 32447) is old, weathered, torn and wrinkled on top. About  $\frac{1}{4}$  of the plant has been cut away exposing to view the glebal cavity.

My examination showed the following: the surface is silvery brown and rough; the base of the specimen plainly shows 7 little finger-like stubs typical of the external columellae of *Myriostoma*, while in the glebal cavity 7 columellae are also visible. The color, columellae, spores and capillitium are identical to those of *Myriostoma coliforme* Corda. This type specimen is evidently an old spore sac of a much weathered and depauperate plant of *M. coliforme* which became detached from the outer star-shaped exoperidium. This is clearly shown by the external stubs of the columellae on the base of the specimen, the typical columellae in the glebal cavity, the silvery brown, rough surface and especially by the spores and capillitium typical of a *Myriostoma*. I have

numerous specimens of *Myriostoma* which have the spore sac torn from the exoperidium, as in Lloyd's plant. In view of the above data *Bovistoides simplex* becomes a synonym of *Myriostoma coliforme*.

*Bovistoides Torrendii* Lloyd. This species was based on a single specimen collected in Brazil, South America, by the Rev. C. Torrend. A description of this plant is given by Lloyd in his Mycological Writings 7: 1116 and is illustrated by figure 2108 showing the specimen natural size while figure 2109 is a line drawing of the capillitium and spores.

The type specimen (Lloyd's no. 32448) is well preserved and is a globose plant about 5 cm. in diameter with a 2-layered peridium having a round central opening in the top, and a short radiating base where it was attached to the substratum (wood); *exoperidium* wrinkled, tough, glabrous, 1-2 mm. thick, dull brown, not deciduous except a small portion around the apical opening. This apical opening does not seem normal but appears as if made by some outside agency, possibly when the plant was collected; *endoperidium* hard, rigid, about 1 mm. thick at stoma, exterior surface brown where exposed, edges cupped into the gleba as if pushed inward by some foreign agency. Sterile base none. *Gleba* in mass dark brown to sooty black consisting of spores, capillitial threads and a hyaline tissue in which the spores and capillitium are embedded. Definite strings of this glebal tissue protrude into the glebal cavity from the walls of the endoperidium. These protruding strings are 3-5 mm. long, and consist of spores and bundles of the capillitial threads. The gleba becomes very powdery and dirty with age. The *capillitial threads* are short, thick with pointed ends, unbranched, brown, solid, walls smooth, 12-16 microns thick in center, 250-600 microns long (see Lloyd's figure 2109). *Spores* globose, fuliginous, 1-guttulate in water mountant, 4-5 microns in diameter; *epispore* black, appearing rough.

The general aspect of this specimen suggests that it was immature when collected and that its true manner of dehiscence is not shown. The plant resembles an unopened *Myriostoma coliforme* but the glebal characters exclude it from this species.

Since the type of *Bovistoides simplex* has been shown to be a synonym of *Myriostoma coliforme*, the question arises as to the

validity of the genus *Bovistoides* and the correct name for *Bovistoides Torrendii*. I am leaving this name unchanged although the plant on which the genus was established is entirely different from *B. Torrendii*. If the genus *Bovistoides* is maintained it will have to be based on the Brazilian plant *B. Torrendii* and the generic description emended.

PHELLORINA MACROSPORA Lloyd.

This species was described from a single plant found in California by S. B. Parish. The type collection (Lloyd's No. 25529) has two labels with it; one on the top of the container reads as follows: "*Phellorina macrospora*, San Bernadino, California, S. B. Parish, Oct. 22, 1912—Type." Inside the box is a label reading "Plants of Southern California No. 8212, Coll. S. B. Parish, Oct. 1912, Mecca, Colorado Desert." Also in the box is a typed manuscript which was published by Lloyd in Vol. VI, Letter 44, note 50 as his original description of this species.

The type specimen consists of one plant having a stipe and a flattened pileus with one side broken off but still in the box. The *pileus* or *sporocarp* is 2 cm. across, apparently sub-globose when fresh, exterior dirty white, more or less scaly and breaking loose around the stipe. *Stipe* 28 mm. tall by 6 mm. thick, yellowish brown, smooth, equal, with a small ball of dirt 7 mm. thick at base; the stipe is percurrent through the pileus forming a *columella* 8 mm. long by 3 mm. thick and apparently attached at its apex to the endoperidium. *Gleba* yellowish brown, rather firm and caked; *capillitium* scant, hyaline, threads flattish to terete; *spores* with a 2-layered wall, subglobose, short elliptical to obovate, truncate, germ pore at apex, very variable in size, 9–11 by 12–16 microns; *epispore* smooth, hyaline, subhyaline to yellowish brown, about 4 microns thick.

This plant is undoubtedly a *Podaxon*—a small, depauperate, immature specimen of *Podaxon pistillaris*. It has the typical sporophore and spores of a *Podaxon* and not those of a *Phellorina*.

Lloyd did not adequately describe this so-called new species of *Phellorina* as the following quotation from his original description shows. "From S. B. Parish, Southern California, I previously

had the opinion that *Phellorina* was probably a monotypic genus as the various named species seem to me very much the same, and all have the same spores, globose, 5–6 microns in diameter. This plant has very large spores 16–18 microns. Mr. Parish found one (immature and not well developed) plant at Mecca, Colorado Desert. In addition to the large spores of this plant, it is of much interest as the genus is of greatest rarity in the United States." No description of the plant is given other than the size of the spores (16–18 microns), not even the shape, color or markings of the spores are noted. I therefore consider the name—*Phellorina macrospora*—as *nomen nudum* in addition to being a synonym of *Podaxon pistillaris*.

· ALBUQUERQUE, NEW MEXICO.

# NOTES ON ARAIOSPORA STREPTANDRA<sup>1</sup>

LELAND SHANOR AND LINDSAY S. OLIVE

(WITH 11 FIGURES)

The genus *Araiospora* Thaxter of the Leptomitaceae is unique among aquatic Phycomycetes in that the oöspores borne singly in the oögonia are surrounded by a cellular envelope which is derived from the periplasm. In North America the species which have been reported have all been collected in New England or New York (1). No reports have hitherto been published of species having been collected south of New York and Rhode Island. Of the four known species, three seem to prefer colder climates while only one has been found in tropical countries (4). On the basis of published data, the two species that are known from the United States are rare and appear to be confined to rather limited areas. *Araiospora pulchra* Thaxter (6), the type species for the genus, has been collected in Maine, Massachusetts, and New York (6, 5, 3), while the other species, *A. streptandra* Kevorkian (2), is known only from collections made around Kingston, Rhode Island and Cambridge, Massachusetts (2). The present report of collections of a form of this second species from North Carolina extends considerably its known geographical distribution in the United States.

## MATERIAL

Dead twigs and branches of Cherry Birch (*Betula lenta* L.) obtained from Harbison Lake, Highlands, North Carolina, by the junior author during August, 1939, were carefully examined by us for the presence of aquatic fungi which might be growing on them when brought into the laboratory. Small tufts of a white mycelium appeared rather abundantly on several of these twigs, and an examination of them revealed that they belonged to an *Araio-*

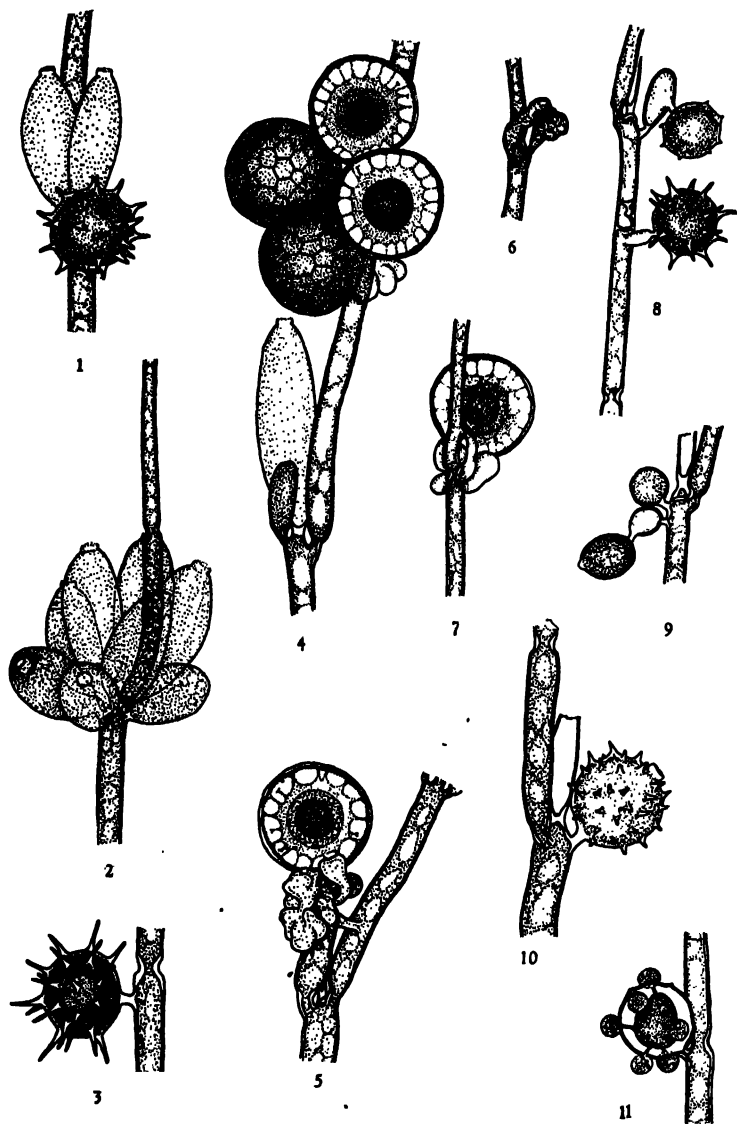
<sup>1</sup> Contribution from the Highlands Biological Laboratory, Highlands, North Carolina.

*spora*. Although the spinose sporangia of these plants differed rather strikingly in several respects from those of *A. streptandra* as described by Kevorkian (2), these differences seemed to us to be within the limits of the possible variation of this species so, largely on the basis of the characteristics of the organs of sexual reproduction, we identified our collection as belonging to Kevorkian's species. No attempt was made to keep the fungus in culture.

#### OBSERVATIONS

**THE THALLUS**—Plants consist of a large basal cell on whose sub-conical apex a number of branches arise and from whose base numerous rhizoids develop. The older branches are found in the center near the tip of the cell while the younger ones grow out more toward the base of the conical portion. The branches are constricted at regular intervals with the posterior segments being shorter and of a larger diameter than those immediately above them. At the point of constriction the hyphal walls are considerably thickened and in many instances the wall deposit at these points completely obstructs the opening between segments. From our observations on these collections it appears that whether or not the opening becomes completely obstructed determines to a large extent whether a segment will develop branches. Branches most frequently occur on the sides of the anterior end of segments and in the majority of the cases we have observed, they developed only when terminal growth became obstructed. This obstruction might be either the formation of a terminal zoösporangium (FIGS. 2, 4) or the complete closing of the opening allowing for protoplasmic communication between segments (FIGS. 8, 9, 10). The walls of segments also appear to be weak where a segment has been cut off completely from the one below and numerous cases have been seen where a branch had become completely severed from the parent plant by a breaking of the wall above an obstructed constriction (FIGS. 8, 9, 10). In older plants the first branches which developed near the tip of the sub-conical base are usually missing with only their stubs remaining on the uppermost part of the basal cell. The fate of these branches has not been determined but the possibility that this fragmentation of a plant might serve as a method of





FIGS. 1-11. *Araiopora streptandra* var. *echimulosphaera*.

vegetative multiplication is suspected, provided the portion that becomes free should settle on a suitable substratum.

**THE ZOÖSPORANGIA**—Zoösporangia of this plant develop at the tip of segments and grow out laterally from the distal end of them. They are of two kinds as is characteristic for the genus.

The thin walled smooth sporangia occur either singly or in clusters of 2-10, vary considerably in size, and are normally clavate or sub-cylindrical in shape (FIGS. 1, 2, 4). The largest clavate or sub-cylindrical sporangia are up to  $117.5\ \mu$  in length by  $41\ \mu$  in diameter at their widest point and develop from the larger segments while the mature smaller ones of this shape are no larger than  $32\ \mu$  long by  $26\ \mu$  in diameter and are most frequently found on tip segments of the hyphae.

All of the thicker walled echinulate sporangia which were observed in our collections were spherical in shape and were more or less covered with numerous rather evenly spaced conical spines which varied considerably in length (FIGS. 1, 3, 8, 10). The diameter of these sporangia measured between  $29.8$ - $48.7\ \mu$  while the spines on them are from  $3.1$ - $20.4\ \mu$  in length and often are slightly curved at their tips. Sporangia of this type usually have between 30 to 50 spines but the largest most echinulate ones may possess as many as nearly a hundred of them. Some of the young spinose sporangia were found to be parasitized by a species of *Rhizophidium* (FIG. 11). Quite a number of cases have been observed where sporangia became arrested in their development for some unknown reason and when development was resumed, tubes were formed which produced at their ends normal functional zoösporangia. The sporangia thus formed may be either the smooth walled or the spinose type (FIGS. 8, 9).

**ORGANS OF SEXUAL REPRODUCTION**—The sexual organs of the plants in our collections correspond rather closely with those described by Kevorkian (2) for plants observed from New England. Oögonia normally develop either singly or in clusters of 2-6 on branches from the distal end of segments (FIGS. 4-7) and the antheridial branches arise on the same segment (FIG. 6) or the one just above it (FIG. 5, 7). Antheridia of our plant are large, decidedly lobed and toruloid in shape, and become appressed to the base of oögonia after twining around its stalk. Stages in fertilization of the egg have not been followed but we can confirm the observations of Thaxter (6) and Kevorkian (2) that the fertilization tube from the antheridium penetrates the oögonial wall and extends into the oögonium to the region of the oöplasm. Mature

oögonia are spherical, usually measure between  $55.2\text{--}65\ \mu$  in diameter, and each contains a single oöspore. Mature oöspores are between  $37.3\text{--}42.5\ \mu$  in diameter and are surrounded by a layer of cell-like structures derived from the periplasm. These peripheral cells are somewhat hexagonal—appearing in a surface view of oögonia and measure  $9\text{--}15.7\ \mu$  across  $\times 6.2\text{--}9.4\ \mu$  deep.

#### DISCUSSION

The principal characteristics on which species within the genus *Araiospora* are separated are (1) position and relationship of the sexual organs, (2) echinulation of the spinose sporangia, and (3) size of the various reproductive structures. The North Carolina plant on the basis of the first and third of these diagnostic criteria would fit Kevorkian's description of *A. streptandra* rather well but it differs strikingly in the characteristics of the spinose sporangia. The shape of the sporangia in Kevorkian's collections was oval to pyriform while the same type of sporangia in our collections is either spherical or nearly so. The echinulate sporangia of our plant are also much more spinose with the spines sometimes somewhat curved at the tips in contrast to the condition of the spiny sporangia as described and figured by Kevorkian. In the text of his paper Kevorkian says that this type of sporangia of his plant possess from 10–15 spines whereas those of ours rarely have less than 30 and usually have more. As many as nearly a hundred have been observed on the largest, most spinose ones. In addition to the characteristics of spinose sporangia, the antheridia of our plant are larger and more toruloid than those described and figured by Kevorkian. It seems evident, therefore, that the plant which we are here reporting is a distinct variety of *A. streptandra* and we propose the following name suggested by the characteristics of the spinose zoösporangia.

#### ***Araiospora streptandra* var. *echinulosphaera* var. nov.**

Echinula-sporangia sphaerica,  $29.8\text{--}48.7\ \mu$  diam.; spinis numerosis, plerumque  $30\text{--}50$ ,  $3.1\text{--}20.4\ \mu$  longitudine.

## SUMMARY

1. A new variety of *Araiospora streptandra* Kevorkian is described as var. *echinulosphaera* collected on Cherry Birch twigs that had fallen into Harbison Lake, Highlands, North Carolina. This is the first report of any species of this rare genus occurring south of New England and New York on the North American continent.

2. The outstanding characteristics of this species are described and its relationship to *Araiospora streptandra* Kevorkian is discussed. Also an unidentified species of *Rhizophidium* is reported to parasitize the immature spinose zoösporangia.

DEPARTMENT OF BOTANY,  
UNIVERSITY OF ILLINOIS,  
URBANA

AND  
DEPARTMENT OF BOTANY,  
UNIVERSITY OF NORTH CAROLINA,  
CHAPEL HILL.

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## EXPLANATION OF FIGURES

All figures drawn with the aid of a Spencer camera lucida. Figs. 2, 3, 6-10,  $\times 250$ ; figs. 1, 4, 5, 11,  $\times 245$ . Fig. 1. Portion of a hypha bearing two empty smooth zoösporangia and a single spiny one which is still full of protoplasm. Fig. 2. Cluster of smooth zoösporangia at the distal end of a segment. Fig. 3. A spinose zoösporangium. Fig. 4. Portion of a hypha with a terminal empty smooth zoösporangium, a young smooth zoösporangium, and a branch arising at the distal end of a segment. A cluster of sexual organs are borne on the branch. Two of the oögonia are shown in

surface view. Fig. 5. Portion of a hypha with an oögonial branch on which there are two oögonia, one mature and one very immature. The antheridial branch in this case arises from the segment immediately above the one from which the oögonial branch developed. Fig. 6. Young sexual branches arising from the distal end of the same segment. Fig. 7. Portion of hypha with reproductive organs. The stalk of the oögonium is completely hidden by the twining antheridial branch which is wrapped around it. Fig. 8. Portion of a hypha bearing two spinose zoösporangia. The upper immature zoösporangium is formed at the end of a tube from a smooth walled one. The branch developed in this case after the segment above became cut off by wall deposit at the constriction. Fig. 9. Portion of a hypha with two small smooth-walled zoösporangia formed at the tip of one segment. One of these zoösporangia has proliferated to form a second smooth-walled zoösporangium. Fig. 10. Portion of a hypha bearing an empty echinulate thick-walled zoösporangium with short spines. Fig. 11. Portion of a hypha bearing an immature echinulate zoösporangium which is parasitized by a species of *Rhizophidium*.

# TWO NEW CHYTRID GENERA <sup>1</sup>

ALMA J. WHIFFEN

(WITH 52 FIGURES)

Two new chytrids, one an epibiotic parasite of *Pythium* and the other an epibiotic parasite of *Rhizophidium*, were obtained by baiting soil collections with boiled grass leaves. Both of these chytrids are new genera of the Rhizidiaceae.

## THE PARASITE OF PYTHIUM

The chytrid parasite of *Pythium* is characterized by its mode of parasitism and manner of spore discharge. The *Pythium* host is parasitized by the tips of the chytrid rhizoids which fasten themselves to the host hyphae but do not penetrate the hyphal wall. Spore discharge is accomplished by the dissolution of the sporangial wall, thus liberating the spores, which swim away shortly after the disappearance of the wall. *Solutoparies* is given as the generic name to indicate the peculiar method of spore discharge. The type species is named *S. Pythii*.

### **Solutoparies** gen. nov.

Thallus entirely extramatrical, monocentric. Sporangia developing by enlargement of zoospore; rhizoidal system much-branched. Spore discharge by dissolution of sporangial wall, liberating the zoöspores which swim away singly. Zoöspore uniguttulate, posteriorly uniciliate. Resting spores unknown.

### **Solutoparies Pythii** sp. nov.

Thallus parasitic. Sporangia ovoid to spherical,  $14.3\ \mu \times 16.4\ \mu$  to  $68.4\ \mu \times 80.3\ \mu$ ; wall spiny, spines conical, up to  $5\ \mu$  in length.

<sup>1</sup> This study has extended over the past two years during the tenure of a research assistantship, supported by grants to Dr. J. N. Couch by the Carnegie Corporation of New York, 1940-41, and by the American Philosophical Society, 1941-42, and during the tenure of a Scholarship at the Highlands Biological Laboratory, Highlands, N. C., summer of 1942.

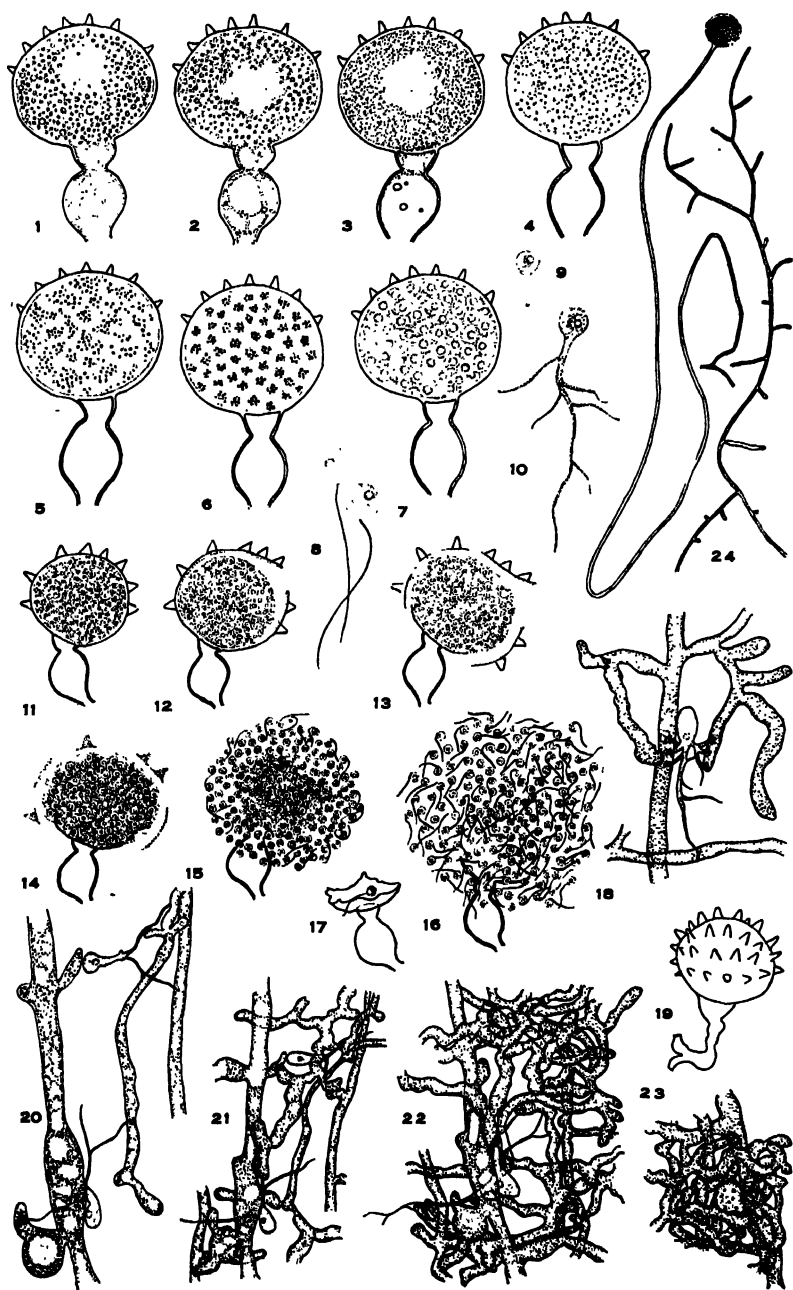
Rhizoidal system cut off by cross wall from mature sporangium, tips of rhizoidal branches adhering to but not penetrating host hyphae. Dissolution of sporangial wall complete except for basal portion, freeing the spore mass, enclosed in a gelatinous matrix; zoöspores separating as surrounding matrix dissolves, swimming away singly. Zoöspores spherical,  $4.5\ \mu$  to  $5.6\ \mu$ , hyaline with single colorless oil globule. Resting spores unknown.

Exoparasite of *Pythium* sp. Collected October, 1940, at Chapel Hill, North Carolina.

*Solutoparies Pythii* was found growing on the grass leaf bait in conjunction with a species of *Pythium*. In an attempt to establish a unifungal culture of the chytrid, mature sporangia were dissected from the leaf and transferred to a piece of boiled grass leaf, immersed in distilled water in a sterile Petri dish. In those culture dishes in which had been placed chytrid sporangia entirely free from *Pythium* hyphae, there appeared no growth of the chytrid. On the leaves, however, which were inoculated with both the chytrid and the *Pythium*, a large number of chytrid sporangia developed among the *Pythium* hyphae. Further study of the cultures revealed that the chytrid was parasitic on the *Pythium*.

Developmental studies of *S. Pythii* were made with chytrid thalli obtained by inoculating the *Pythium* host on hemp seed in water and on agar with spores of the parasite. The agar cultures were used particularly to study the early stages of spore germination and the host parasite relationships.

About one hour after the zoöspore has been placed on agar the germ tube makes its appearance (FIG. 9). Up to a certain stage, the development which follows the germination of the zoöspores is accomplished much more rapidly than that of a comparable degree of development of a typical saprophytic chytrid. In a few hours the rapid elongation and branching of the germ tube results in a germling with a well established rhizoidal system (FIG. 10). Spores on agar plates on which the *Pythium* host is not growing, reach this germling stage but are unable to develop any further. Continued growth of the thallus, therefore, is dependent upon contact being made with the host by one or more of the rhizoidal branches (FIG. 18). Enlargement of the thallus is accompanied by continued branching of the rhizoids, each rhizoidal branch consti-

FIGS. 1-24. *Solutoparies Pythii*.



tuting an additional potential means of absorbing nutriment from the host. As the rhizoidal system increases in extent, there is a corresponding increase in the diameter of the primary rhizoids so that the portion of the rhizoid immediately below the sporangium becomes greatly swollen (FIG. 19).

As the sporangium attains its mature size, blunt pointed spines appear in a cyclic arrangement over the apical half of the sporangium (FIG. 19). Not all sporangia, however, are spiny-walled. Shortly after the formation of the spines the contents of the rhizoids begin to disappear (FIG. 2) and a cross wall develops, cutting off the sporangium from the rhizoidal system (FIG. 3). When the cross wall is complete, the process of the differentiation and cutting out of the spores begins.

The formation of the zoöspores is best followed by observing the changes in the form and arrangement of the oil globules and vacuoles. In the early stages of thallus development the oil globules are large and irregular in size and no well defined vacuoles are visible. As the sporangium ceases to enlarge, a large central vacuole appears within the sporangium (FIG. 1). This central vacuole persists during the stages in which the sporangium is cut off from the rhizoids and the oil globules become smaller and more uniform in size (FIG. 3). The disappearance of the central vacuole is followed by the appearance of numerous small vacuoles scattered throughout the protoplasm (FIG. 4). Then the vacuoles become less evident as the oil globules aggregate in small groups (FIG. 5). The aggregation of the oil globules continues (FIG. 6) until the small globules of each group coalesce into a single large globule (FIG. 7). Around each oil globule a spore is then cut out.

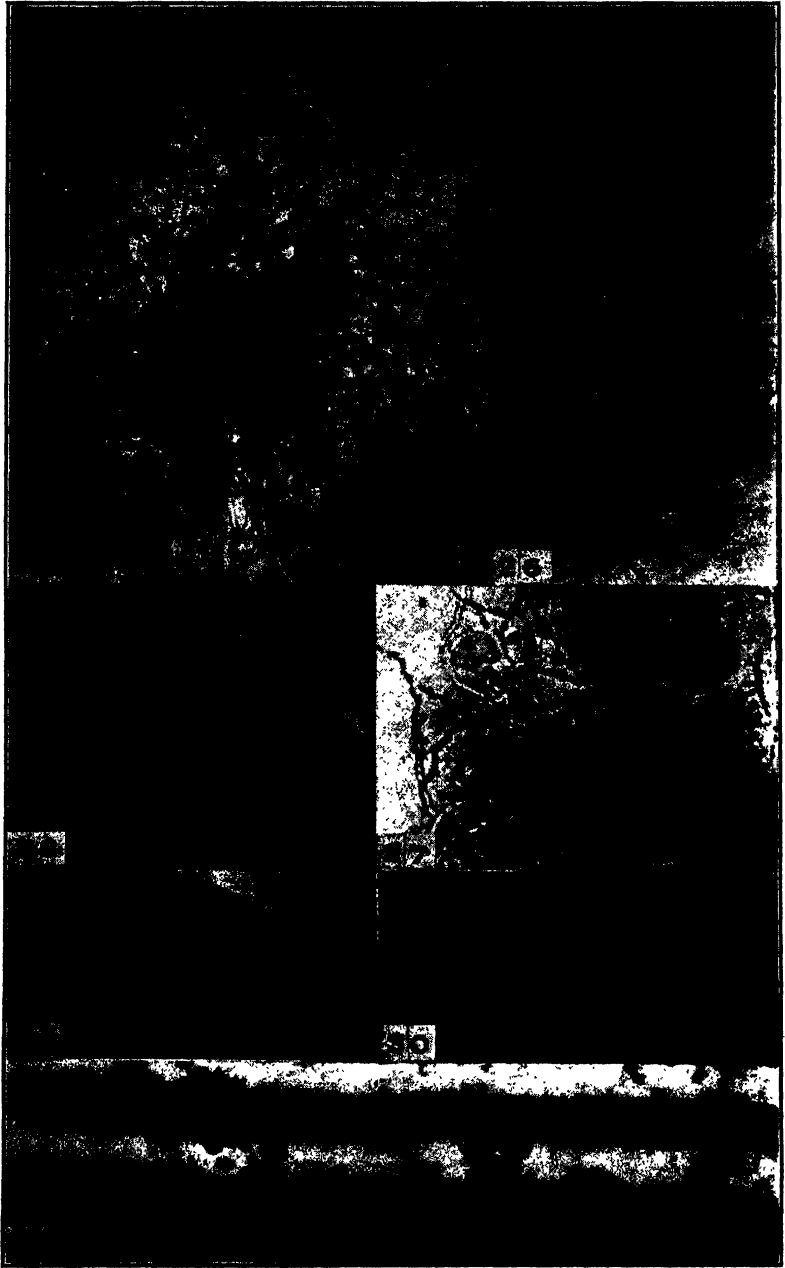
The first indication of spore discharge is the swelling and thickening of the sporangial wall (FIG. 12). Expansion of the wall is accompanied by dissolution of the wall substance (FIGS. 13 and 14), the spines being the last portion to dissolve (FIG. 15). Slowly as the gelatinous matrix enclosing the spores becomes soluble, the zoöspores become active and swim away one by one. All that then remains of the sporangial wall is an irregular collar about the base of the rhizoid (FIG. 17). Each zoöspore is spherical with a long cilium and varies from the typical chytrid spore only in the position

of the single oil globule, which is placed anteriorly and to one side of the center of the spore as it swims (FIG. 8).

It is interesting to observe the effect of the parasite on its host. At a low magnification a young chytrid thallus may be located by the tangled mass of *Pythium* hyphae which surrounds it (FIG. 25). A culture of the host not infected by *S. Pythii* does not produce these knotted masses of hyphae. In agar cultures the progress of the branching of the host about the parasite thallus can be easily followed from the early stages of spore germination of the parasite to its maturity. In figure 20 are shown two germings of *S. Pythii*, whose rhizoids are attached to three hyphae of the *Pythium* host. Five hours later the abnormal branching of the host has begun (FIG. 21) and after eight more hours the thalli of the parasite are almost obscured by the *Pythium* hyphae (FIG. 22). By the end of the next fifteen hours the chytrid thalli are no longer visible. Branching of the host continues through an increasing area until the parasite has attained its mature size, when disintegration of the parasitized hyphae begins (FIG. 27).

Because of the fineness of the rhizoidal tips of the chytrid, it was difficult to determine the exact relationship of the parasitic rhizoids to the host hyphae. The rhizoids of the parasite do not ramify through nor enter the host but frequently they wrap around the outside of the hyphae. No haustoria of the parasite could be detected within the *Pythium* hypha but where the tip of the rhizoid is attached to the hyphal wall, there is a noticeable aggregation of granules of the host protoplasm just beneath (FIG. 18). The portion of the hypha attacked by the parasite swells but slightly so that hypertrophy of the host is expressed only in increased and abnormal branching of the hyphae. This reaction of the host, of course, is well adapted to the development of the parasite in that the number of hyphal branches in its immediate vicinity from which the chytrid parasite may obtain food is thereby greatly multiplied.

It has not been possible to determine the species of *Pythium* on which *S. Pythii* is parasitic. The *Pythium* was grown on maltose-peptone and corn meal agars as well as on hempseeds and boiled carrot in water cultures but on none of these substrata were



FIGS. 25-31. Photomicrographs of *Solutoparies Pythii* and *Septosperma Rhizophidii*.

oögonia produced. The most striking characteristic of this *Pythium* is its ability to discharge large numbers of zoöspores in water cultures. A period of active spore discharge results in the formation of many large spherical masses of encysted spores. The diameter of the sporangium is equal to or only slightly greater than the diameter of the axial hyphae. In the undifferentiated filamentous character of the zoösporangium, this species of *Pythium* conforms to Schroeter's concept of his genus *Nematosporangium*. In figure 24 are illustrated a typical sporangium in the act of discharging spores and the habit of mycelial branching. A brief description is given below as an aid to the identification of this species of *Pythium* in the future.

*PYTHIUM*, species undetermined.

Mycelium saprophytic. Axial hyphae,  $6.1\ \mu$  to  $8.2\ \mu$ , lateral branches  $2.4\ \mu$  to  $4.1\ \mu$  in diameter, coming off mostly at right angles to axial hyphae. Zoösporangium consisting of undifferentiated mycelial elements, rarely branched,  $7.2\ \mu$  to  $8.5\ \mu$  in diameter. Zoöspores  $6.5\ \mu$  to  $7.8\ \mu$  in diameter when encysted; zoöspore cysts collecting in large, spherical masses. Conidia absent. Oögonia not observed.

One chytrid genus has been described which resembles *Solutoparies Pythii* in its mode of spore discharge. In 1885 A. Borzi (1) described a new genus, *Nowakowskia*, and a new species, *N. Hormothecae*, which is parasitic on the germinating zoöspores of *Hormotheca Sicula*. Though *N. Hormothecae* parasitizes an alga rather than a Phycomycete, in its extramatrical habit it is similar to *S. Pythii*. Borzi, however, states that the rhizoids of his species bore through the cell wall and press into the interior of the algal cell. Several germinating zoöspores may be parasitized thus by a single thallus of *Nowakowskia Hormothecae*. Spore discharge in *Nowakowskia* is accomplished by the dissolution of the sporangial wall just as in *Solutoparies*. The behavior of the zoöspores as described by Borzi is peculiar. After the disappearance of the sporangial wall, the spore mass swims around in the water like a colony of *Volvox*. The spores adhere so closely together that when the swimming spore ball strikes an obstacle, it flattens, elongates on one side, and draws itself around the obstacle,

later resuming its spherical form. Eventually groups of spores detach themselves from the spore mass. Each group assumes a spherical form and begins to rotate in the water. The spore balls continue to break up into smaller and smaller spheres until the spores are completely separated and swim about singly. The sporangium and spores of *N. Hormothecae* are small in size. The diameter of the sporangium varies from 4 to 16  $\mu$  and the body of the zoospore measures only one micron in length. Fischer (4) considers *Nowakowskia* as a doubtful genus and suggests that the organism described by Borzi is a Rhizopod. The Volvox-like behavior of the zoospores of *Nowakowskia* after their discharge is so distinctive that any species placed in this genus should agree with the type species in this respect. Therefore, though *S. Pythii* is similar to *Nowakowskia Hormothecae* in regard to the manner of spore discharge, it is necessary to erect a new genus for our parasite of *Pythium*.

#### THE PARASITE OF RHIZOPHIDIUM

The correct disposition of the chytrid parasite of *Rhizophidium* is a difficult problem. Because of the lack of a definite, branched rhizoidal system, this chytrid could be considered as a new species of *Phlyctidium* (*Tylochytrium* Karling 7). The structure of the resting body, however, is distinct from that of all species of *Phlyctidium*, in which the resting body is known, except *P. anomalum* Couch (3). The resting body of *P. anomalum* is a cylindrical body, divided by a cross wall into two portions, an apical portion containing several oil globules and an empty basal portion. Such a resting body is possessed by our parasite of *Rhizophidium*. The resting body has been observed in only two other species of *Phlyctidium* in addition to *P. anomalum*. A spherical resting body has been described by A. Braun (2) for *Phlyctidium laterale*. This species was transferred to *Rhizophidium* by Rabenhorst (6), and was retained in this genus by Fischer (4). Von Minden (8) does not recognize the transfer of *P. laterale* to *Rhizophidium*. Karling (6), however, has recollected this species and has discovered the presence of delicate rhizoids which necessitates the placing of this species in *Rhizophidium*. Karling also figures a spherical

resting body, containing a single large oil globule. *Phlyctidium anatrofum* (Braun) Sparrow has been recently studied by Sparrow (13), who transferred this species to *Phlyctidium* from *Rhizophidium* where it had been placed by Fischer. An ovoid resting body was described by Braun for this species but was not observed by Sparrow.

The validity of *Phlyctidium* as a genus has often been questioned. Schroter (11) and Fischer (4) do not recognize *Phlyctidium* but Serbinow (12) and von Minden (8) regard it as a valid genus. Scherffel, Sparrow, and Karling all consider *Phlyctidium* as inadequately separated from *Rhizophidium*. Scherffel (10) believes that the difference between a branched and an unbranched rhizoid is not so fundamental that it leads to a sharp generic distinction. A similar opinion is expressed by Sparrow (13) and Karling (7).

The resting body structure of the chytrid may be considered to be distinctive when it differs markedly from the spherical form with a large central oil globule. Furthermore, when the zoösporangial stage of the chytrid lacks distinguishing morphological characters, it may be necessary to resort to the resting body stage for characters of taxonomic value. Since the structure of the resting body of *Phlyctidium anomalum* Couch is different from that of any other previously described chytrid, with one possible exception, the discovery of our chytrid form, which possesses a similar resting body, gives added significance to the peculiar type of resting body found in Couch's species. Scherffel (10, Pl. 9, Fig. 16 a, b) figures a stalked resting body which he found on *Gomphonema micropus* and which he considered to be the resting body of *Podochytrium clavatum* Pfitzer, previously unknown. It may or may not be significant that whereas all other species of *Phlyctidium* are parasitic on algae, *P. anomalum* and the chytrid now being discussed are parasites of two chytrid genera, *Phlyctidium* and *Rhizophidium*, respectively. Therefore, it now seems advisable to establish a new genus, in which would be placed *P. anomalum* Couch as the type species and our chytrid parasite of *Rhizophidium*. This genus is characterized by the possession of an elongated resting body, which is divided by a cross wall into an empty basal portion and an apical portion filled with protoplasm and one to many oil globules.

**Septosperma** gen. nov.

Thallus extramatrical, eucarpic. Zoösporangia, arising by enlargement of zoöspore, spherical, ovoid, or ellipsoid, each sporangium with a single exit pore. Zoöspores uniguttulate and posteriorly uniciliate. Resting bodies elongated, ellipsoid to clavate, divided by cross wall into an empty proximal portion and a distal portion containing protoplasm and one or more oil globules. Zoösporangia and resting bodies attached to host by bulbous, discoid, or slightly branched haustorium.

**Septosperma anomala** comb. nov.

*Phlyctidium anomalum* Couch, Jour. Elisha Mitchell Sci. Soc. 47: 256. pl. 17. figs. 69–83. 1932.

The following description is taken from Couch (3).

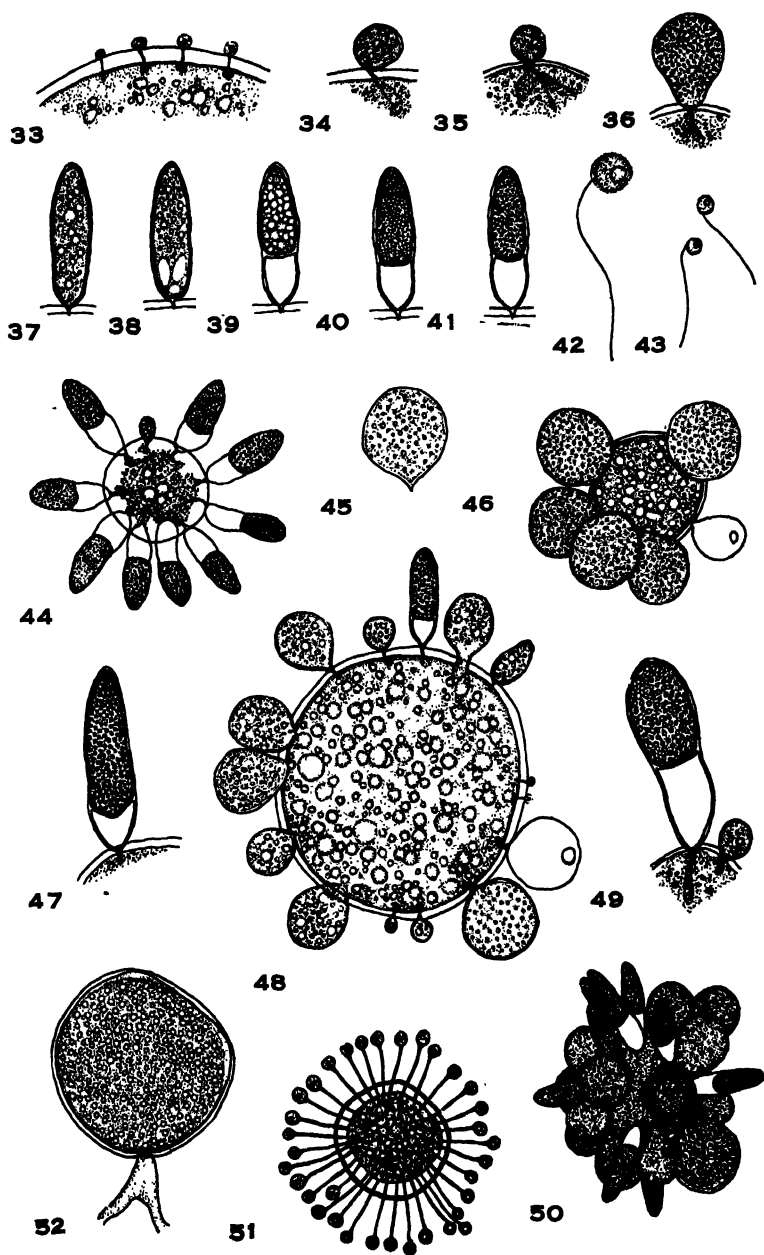
Sporangia sessile, ovoid, or ellipsoid,  $4.2\text{--}5.5 \times 7.3\text{--}11.7 \mu$ , anchored to the host by a very small, bulbous, or discoid base. Spore development as in *Rhizophidium globosum*. Spores in sporangium about  $1.8 \mu$  thick with a single glistening droplet. Swimming spores not seen. Sporangial discharge through an apical pore. Sporangium collapsing more or less after spore discharge. Resting cells formed from a cell of about the same size and shape as mature sporangium. The protoplasm collects in the distal half of this cell leaving the proximal half empty and around the protoplasm a rather thick wall is formed. Resting cell with 1–3 oil globules. Rarely the mature resting cell may occupy the entire "parent" cell being elliptical in shape. Parasite on *Phlyctidium Bummilleriae* Couch.

**Septosperma Rhizophidii** sp. nov.

Zoösporangia varying in shape from spherical to pyriform,  $8.2 \mu$  to  $24.4 \mu$  in diameter, wall smooth with a single inconspicuous exit pore at maturity. Zoöspores spherical,  $1.6 \mu$  to  $2.0 \mu$  in diameter. Resting sporangia clavate, stalked,  $4.1 \mu \times 16.4 \mu$  to  $6.1 \mu \times 25.1 \mu$ , at maturity stalk empty of protoplasm, apical portion filled with numerous small oil globules. Germination of resting sporangia not observed.

Parasitic on *Rhizophidium macrosporum* at Chapel Hill and Highlands, North Carolina.

*Septosperma Rhizophidii* has the *Rhizidium* type of development in which enlargement of the spore body gives rise to the mature

FIGS. 33-52. *Septosperma Rhizophidii*.



sporangium or resting body. The wall of the host is penetrated by the germ tube of the germinating zoospore (FIG. 33). The swelling of the end of the germ tube very soon after its entry into the host protoplasm indicates the formation of a haustorium, which attains its maximal size before the enlargement of the sporangium is completed (FIGS. 34 and 35). The haustorium appears as an aggregation of protoplasm that may be sac-like (FIG. 34) or tenuous and branched (FIG. 35) and is distinguished from the clear host protoplasm only by its greater density.

Usually the mature zoösporangium is spherical except for the conical basal portion, of which the haustorium is a continuation. This basal portion is sometimes expanded so that the sporangium is raised above the surface of the host sporangium.

The actual discharge of the zoöspores was not observed though frequently sporangia were found from which the spores had recently escaped. Discharge of the spores is accomplished through a single circular opening in the sporangial wall. There is no operculum and no indication of a protruding exit papilla can be found on the mature sporangium. The zoöspores are about one fourth the size of the zoöspores of the host species of *Rhizophidium* (FIGS. 42 and 43).

The resting body is the most conspicuous phase of the life history of *S. Rhizophidii*. In the early stages of the epidemic caused by this parasite both zoösporangia and resting bodies can be found on the same sporangium of the host. By the end of the epidemic the majority of the host sporangia are covered by resting bodies of *S. Rhizophidii*. In its early stage of development the resting body is indistinguishable from a young sporangium. Elongation of the thallus indicates that it is to become a resting body. As the resting body matures, oil globules and protoplasm become concentrated in the distal end of the resting body. The proximal portion becomes vacuolated and finally empty of protoplasm as the cross wall forms (FIGS. 38 and 39). The large oil globules break up into numerous small oil globules, which are so compactly arranged as to give the contents of the resting body a homogenous appearance (FIG. 41). The stalk of the resting body is usually shorter than the portion containing the oil globules though it may be longer (FIG. 49). Germination of the resting bodies was not observed.

The zoöspores of the parasite develop only on immature zoösporangia of their host, *i.e.* sporangia in which the spores have not been cut out. Development of the host sporangium is stopped by the attack of the parasite although a large number of thalli may parasitize the *Rhizophidium* sporangium before complete disintegration of the host protoplasm is effected. It was not possible to obtain growth of the parasite apart from its host.

The host of *Septosperma Rhizophidii* is a saprophytic species of *Rhizophidium* which in the size and shape of the zoösporangia and the form of the exit papillae agrees well with Karling's (5) description of *R. macrosporum*. Most of the species of *Rhizophidium* are known as parasites of algae and oöspores of the Oömycetes and few species have been described as occurring saprophytically on such substrata as pollen and other plant parts. Identification of the species of *Rhizophidium* by the substratum or host on which it is found growing is complicated by the ability of some species of *Rhizophidium* as *R. carophilum* to grow saprophytically on leaves and synthetic media and parasitically on the oöspores of *Achlya*. The host of *S. Rhizophidii* showed a remarkable tendency toward self parasitism. Attempts of the *Rhizophidium* zoöspores to germinate on a sporangium of their own species resulted in the immediate plasmolysis of the protoplasm of the sporangium (FIG. 51).

#### SUMMARY

Two parasitic chytrids, each constituting a new genus, were isolated from soil collections. Spore discharge by the dissolution of the sporangial wall is characteristic of the first genus, *Solutoparies*. The type species, *S. Pythii*, is parasitic on *Pythium*.

A new genus, *Septosperma*, is erected for *Phlyctidium anomalum* Couch and the second parasitic chytrid, *S. Rhizophidii*, both of which possess an elongated resting body, divided by a cross wall into an empty basal portion and an apical portion containing protoplasm and one or more oil globules. *Septosperma Rhizophidii* parasitizes *Rhizophidium*.

DEPARTMENT OF BOTANY,  
UNIVERSITY OF NORTH CAROLINA,  
CHAPEL HILL, NORTH CAROLINA.

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## EXPLANATION OF FIGURES

FIGS. 1-23. *Solutoparies Pythii*. Figs. 1-7. Stages in spore formation in zoösporangium,  $\times 400$ . Fig. 1. 9:00 A.M., the sporangium has attained its mature size. Fig. 2. 3:00 P.M., vacuolization in base of rhizoid has begun prior to formation of wall cutting off the sporangium from the rhizoidal portion of the thallus. Fig. 3. 8:00 P.M., the rhizoids are cut off from the sporangium and the oil globules have become small and uniformly distributed in the protoplasm. Fig. 4. 9:00 A.M., the central vacuole has disappeared and numerous small vacuoles have appeared throughout the sporangium. Fig. 5. 1:00 P.M., the oil globules are beginning to aggregate. Fig. 6. 7:00 P.M., the oil globules are arranged in discrete groups. Fig. 7. 10:00 A.M., the oil globules have coalesced and the spores are cut out, each spore containing a single oil globule. Fig. 8. Two zoöspores showing eccentric position of the oil globule,  $\times 860$ . Figs. 9 and 10. Stages in the germination of the zoöspore,  $\times 560$ . Fig. 9. Zoöspore with germ tube. Fig. 10. Young germling with developing rhizoidal system (unless the rhizoids make contact with the host, development of the thallus does not go beyond this stage). Figs. 11-17. Spore discharge,  $\times 350$ . Fig. 11. Mature sporangium. Fig. 12. The sporangial wall has begun to swell and to break. Fig. 13. Further dissolution of the wall. Fig. 14. Spines not yet dissolved. Fig. 15. The wall has completely disappeared and the spores

begin to free themselves from the gelatinous matrix in which they are imbedded. Fig. 16. The gelatinous matrix has disappeared and the spores are beginning to swim away. Fig. 17. The basal portion of the sporangial wall remains attached to the rhizoid. Fig. 18. Young thallus, grown on agar, showing the nature of the host-parasite relationship,  $\times 350$ . Fig. 19. Surface view of zoösporangium,  $\times 350$ . Figs. 20–23. Effect of the parasite on its host. Stages in increased branching of the host drawn from agar cultures,  $\times 350$ . Fig. 20. 10:00 A.M., two germings making contact with host hyphae. Fig. 21. 3:00 P.M., branching of the host about the parasite has begun. Fig. 22. 11:00 P.M., thalli of the parasite almost obscured by branching of the host. Fig. 23. 12:00 M., the upper parasite thallus of Fig. 22 just before being covered over by host hyphae.

FIGS. 25–31. Photomicrographs of *Solutoparies Pythii* and *Septosperma Rhizophidii*. Fig. 25. Tangled mass of branched *Pythium* hyphae on agar indicating the position of a thallus of *S. Pythii*,  $\times 120$ . Fig. 26. Young thallus of *S. Pythii* on agar,  $\times 430$ . Fig. 27. Mature thallus of *S. Pythii* on agar,  $\times 450$ . Fig. 28. An unparasitized zoösporangium of *Rhizophidium* and one parasitized by *S. Rhizophidii*,  $\times 150$ . Fig. 29. Resting bodies of *S. Rhizophidii*,  $\times 750$ . Fig. 30. Zoösporangia and resting bodies of *S. Rhizophidii*,  $\times 450$ . Fig. 31. Habit view of *S. Rhizophidii* and its host, *Rhizophidium macrosporum*, on a grass leaf,  $\times 250$ .

FIGS. 33–52. *Septosperma Rhizophidii*. Fig. 33. Zoöspores germinating on host,  $\times 850$ . Figs. 34 and 35. Two young thalli showing the nature of the haustorium,  $\times 850$ . Fig. 36. Mature thallus of the parasite,  $\times 850$ . Figs. 37–41. Stages in maturation of the resting body,  $\times 600$ . Fig. 42. Zoöspore of host, *Rhizophidium*,  $\times 850$ . Fig. 43. Zoöspores of the parasite, *S. Rhizophidii*,  $\times 600$ . Fig. 44. Resting bodies on a disintegrating zoösporangium of host,  $\times 850$ . Fig. 45. Detached zoösporangium of parasite,  $\times 600$ . Fig. 46. Mature zoösporangia of the parasite on an immature zoösporangium of *Rhizophidium*,  $\times 600$ . Fig. 47. Resting body with a short basal portion,  $\times 850$ . Fig. 48. Zoösporangium of *Rhizophidium* with parasite in various stages of development,  $\times 600$ . Fig. 49. Resting body with a long basal portion,  $\times 850$ . Fig. 50. Habit sketch of the parasite on its host,  $\times 530$ . Fig. 51. Zoöspores of *Rhizophidium* attacking a zoösporangium of *Rhizophidium* with plasmolysis as the evident result,  $\times 300$ . Fig. 52. Mature zoösporangium of the host, *R. macrosporum*,  $\times 300$ .

## NOTES ON OKLAHOMA CERCOSPORAE—II

W. WINFIELD RAY

Recent collections of species of *Cercospora*, taken primarily in 1941, have been sent to Dr. C. D. Chupp for examination and identification. Among these specimens were discovered 4 new species and 16 species not heretofore recorded for Oklahoma. Previously, 5 new species of *Cercospora* were described by the writer and 12 species listed as occurring on various hosts.<sup>1, 2</sup>

The writer is indebted to Dr. Chupp for suggesting the names and the technical descriptions of the species herein described and for the identification of the 16 species listed.

The following names are proposed:

### 1. *Cercospora cocculicola* sp. nov.

Maculae suborbiculares vel angulares, 1–4 mm. diametro, atro rubro-brunneae et saepe marginibus latibus rubro-brunneis restrictae, interdum cum centribus cinereis; plerumque fungus hypophyllus sed interdum amphigenus; stromatis globosis et nigris, 15–40  $\mu$  diametro; plerumque fasciculis dense; conidiophoris dilute olivaceo-brunneis, in masse nigris, uniformis in coloris et latitudinis, parce septatis, raro ramosis, undulatis, tortuosis, vel 1–3 geniculatis, ad apices rotundatis vel conicis cum cicatricibus sporarum minutis, 2–3.5  $\times$  15–90  $\mu$ ; conidiis dilute subflavo-olivaceis, obclavato-cylindricis, conidiis longissimis distincte obclavatis, rectis vel curvatis, indistincte pluriseptatis, ad bases obconicis, ad apices rotundatis vel conicis, 2–3.5  $\times$  20–100  $\mu$ .

Hab. in foliis *Cocculus carolinus* (L.) DC., Stillwater, Oklahoma.

Leaf lesions subcircular to angular, 1–4 mm. in diameter, dark reddish-brown and often surrounded with a wide irregular burnt-sienna margin, sometimes with a gray center; fruiting principally hypophyllous, but sometimes amphigenous; stromata globular and black, 15–40  $\mu$  in diameter; fascicles mostly dense; conidiophores pale olivaceous brown, rather dark in mass, color and width uniform, sparingly septate, rarely branched, undulate, tortuous or 1–3 geniculate, apices rounded to conic with a minute spore scar, 2–3.5

<sup>1</sup> Ray, W. W. A new *Cercospora* from Oklahoma. *Mycologia* 32: 271. 1940.

<sup>2</sup> Ray, W. W. Notes on Oklahoma *Cercosporae*. *Mycologia* 33: 174–177. 1941.

$\times 15\text{--}90\ \mu$ ; conidia pale yellowish olivaceous, obclavato-cylindric, the longest ones being distinctly obclavate, straight or curved, indistinctly multiseptate, bases obconic, tips rounded to conic,  $2\text{--}3.5 \times 20\text{--}100\ \mu$ .

HABIT: On leaves of *Cocculus carolinus* (L.) DC. in Stillwater, Oklahoma, July 1941.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. 29641.

This fungus differs from *Cercospora Cocculi* Syd., which has conidia and conidiophores  $3.5$  to  $6\ \mu$  in width. It is distinct also from any of the other species described on the *Menispermaceae*.

## 2. *Cercospora Kolkwitziae* sp. nov.

Maculae orbiculares vel irregulares,  $0.5\text{--}12$  mm. longitudo, saepe confluentae et grandes, sordide rubro-brunneae cum centribus caesiobrunneis vel cum 1-multis maculis albus; fungus amphigenus sed copiosior in inferiore superficie; stromatis solum cellis paucis, brunneis; fasciculis cum  $2\text{--}20$  conidiophoris; conidiophoris mediocriter atrobrunneis sed ad apices leviter pallidis et attenuatis, pluriseptatis, non-ramosis, rectis vel undulatis vel leniter geniculatis, cicatricibus sporarum mediocriter ad apicibus subtruncatis,  $3\text{--}4.5 \times 40\text{--}300\ \mu$ ; conidiis hyalinis, acicularis vel interdum obclavatis vel cylindricis, rectis vel curvatis, indistincte pluriseptatis, ad bases truncatis vel obconicis, ad apices subacutis,  $1.5\text{--}3 \times 20\text{--}150\ \mu$ .

Hab. in foliis *Kolkwitzia amabilis* Graebn., Stillwater, Oklahoma.

Leaf lesions circular to irregular,  $0.5\text{--}12$  mm. in length, often confluent and covering large areas, dull reddish-brown with greyish-brown center or with one or more white flecks in each brown area; fruiting amphigenous but more abundant on the lower leaf surface; stromata of only a few brown cells; fascicles  $2\text{--}20$  stalks; conidiophores medium dark brown but slightly paler and attenuate toward the tips, multiseptate, not branched, straight to undulate or mildly geniculate, medium spore scar at the subtruncate apex,  $3\text{--}4.5 \times 40\text{--}300\ \mu$ ; conidia hyaline, acicular or sometimes obclavate to cylindric, straight to curved, indistinctly pluriseptate, truncate to obconic at the bases, tips subacute,  $1.5\text{--}3 \times 20\text{--}150\ \mu$ .

HABIT: On leaves of *Kolkwitzia amabilis* Graebn. in Stillwater, Oklahoma, Sept. 9, 1941. This species on the same host was collected also by Geo. W. Carver at Tuskegee, Alabama, Aug. 12, 1935.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. 29624.

This new species differs noticeably from *Cercospora Weigeliae* Ellis & Ev. in possessing longer and darker conidiophores.

### 3. *Cercospora Physocarp* sp. nov.

Maculae suborbiculares vel angulares, 0.5–4 mm. diametro, crebro confluentae, rubro-brunneae, maculae antiquissimae raro cum centribus cinereis minibus; plerumque fungus hypophyllus; stromatis levis vel prope nullis; fasciculis plerumque cum 2–10 conidiophoris; conidiophoris dilute ad bases sed apices angustatis et dilutiore, parce septatis, leviter geniculatis, non-ramosis, prope rectis, cicatricibus sporarum mediocris ad apicibus subtruncatis,  $3-5 \times 30-150 \mu$ ; conidiis acicularis et hyalinis, indistincte pluriseptatis, ad bases truncatis, ad apices acutis,  $2-3.5 \times 25-75 \mu$ .

Hab. in foliis *Physocarpus bracteatus* Rehd., Stillwater, Oklahoma.

Leaf lesions subcircular to angular, 0.5–4 mm. in diameter, frequently confluent, reddish-brown, oldest spots rarely with small gray centers; fruiting principally hypophyllous; stromata slight or almost none; fascicles mostly 2–10 stalks; conidiophores pale at the bases but paler and narrowed toward the tips, sparingly septate, slightly geniculate, not branched, almost straight, medium spore scar at subtruncate tips,  $3-5 \times 30-150 \mu$ ; conidia acicular and hyaline, indistinctly multiseptate, tips acute, bases truncate,  $2-3.5 \times 25-75 \mu$ .

HABIT: On leaves of *Physocarpus bracteatus* Rehd. in Stillwater, Oklahoma, August 26, 1941.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. 29639.

Two species of *Cercospora* have been described as occurring on *Spiraea* with which *Physocarpus* has by some been made synonymous. The type of *C. Spiraeae* Thum. is a species of *Cercospora* and *C. Rubigo* Cooke & Hark. is a species of *Cylindrosporium*.

### 4. *Cercospora Corylina* sp. nov.

Maculae suborbiculares vel angulares et irregulares, 1–12 mm. diametro, saepe confluentae, rubro-brunneae vel atro rubro-brunneae; fungus hypophyllus; stromatis solum cellis paucis, brunneis; fasciculis cum 2–8 conidiophoris; conidiophoris dilute vel mediocris brunneis sed ad apices angustatis et dilutiore, pluriseptatis, non-ramosis, 0–3 geniculatis, cicatricibus sporarum mediocris ad apicibus subtruncatis,  $3-4.5 \times 40-250 \mu$ ; conidiis hyalinis, acicularis, rectis vel curvatis, indistincte pluriseptatis, ad bases truncatis, ad apices acutis,  $3-4.5 \times 40-150 \mu$ .

Hab. in foliis *Corylus rostrata* Ait., Stillwater, Oklahoma.

Leaf lesions subcircular to angular and irregular, 1–12 mm. in diameter, often confluent, reddish-brown to dark reddish-brown; fruiting hypophyllous; stromata only a few cells, brown; fascicles with 2–8 stalks, pale to medium brown but paler and narrowed toward the tip, multiseptate, not branched, 0–3 geniculate, medium brown spore scar at subtruncate tips,  $3-4.5 \times 40-250 \mu$ ; conidia hyaline, acicular, straight to curved, indistinctly multiseptate, bases truncate, tips acute,  $3-4.5 \times 40-150 \mu$ .

HABIT: On leaves of *Corylus rostrata* Ait. and *C. americana*  $\times$  *avellana* in Stillwater, Oklahoma, September 17, 1940.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. 31434.

The fungus, *Cercospora Coryli* Mont., differs from the species described above in having short conidiophores and colored, cylindric conidia.

The following species have been deposited in the Cryptogamic Herbarium at the Oklahoma A. and M. College:

5. *Cercospora adusta* Heald & Wolf.  
On *Ligustrum ovalifolium* Hassk., Stillwater, Aug. 8, 1941, No. 2222.
6. *Cercospora Althacina* Sacc.  
On *Althaea rosea* L., Stillwater, May 7, 1941, No. 2215.
7. *Cercospora angulata* Winter.  
On *Philadelphus coronarius* L., Lawton, Oct. 19, 1940, No. 2282; *P. grandiflorus* Willd., Stillwater, Aug. 21, 1941, No. 2227; *P. Lemoinei* Lem., Stillwater, Sept. 18, 1941, No. 2208.
8. *Cercospora avicularis* Winter.  
On *Polygonum pennsylvanicum* L., Stillwater, Sept. 17, 1941, No. 2231.
9. *Cercospora Callicarpae* Cooke.  
On *Callicarpa americana* L., Poteau, Aug. 25, 1941, No. 2224.
10. *Cercospora Catalpae* Winter.  
On *Catalpa bignonioides* Walt., Comanche, Oklahoma, Oct. 25, 1941, No. 2312.
11. *Cercospora Davisii* Ellis & Ev.  
On *Melilotus alba* Desr., Stillwater, May 21, 1941, No. 2228; *M. officinalis* (L.) Lam., Stillwater, May 20, 1941, No. 2212.
12. *Cercospora desmodiicola* Atk.  
On *Desmodium canescens* (L.) DC., Stillwater, Oklahoma, Aug. 14, 1939, No. 863.
13. *Cercospora Elaeagni* Heald & Wolf.  
On *Elaeagnus angustifolia* L., Stillwater, Aug. 30, 1941, No. 2210.
14. *Cercospora granuliformis* Ellis & Holw.  
On *Viola papilionaceae* Pursh., Stillwater, July 25, 1941, No. 2218.
15. *Cercospora lathyrina* Ellis & Ev.  
On *Lathyrus latifolius* L., Perkins, July 14, 1941, No. 2229.



16. *Cercospora Pentstemonis* Ellis & Kellerm.  
On *Pentstemon Cobaea* Nutt., Pawnee, Oklahoma, July 1941, No. 2214.
17. *Cercospora Petersii* (Berk. & Curt.) Atk.  
On *Smilax Bona-Nox* L., Ripley, Sept. 10, 1941, No. 2211.
18. *Cercospora Pulcherrimae* Tharp.  
On *Euphorbia marginata* Pursh., Lawton, Oklahoma, Oct. 1941, No. 2241.
19. *Cercospora rosicola* Pass. (*Mycosphaerella rosicola* (Pass.) Davis.)  
On *Rosa* sp. (Cult.), Stillwater, Aug. 26, 1941, No. 2225.
20. *Cercospora Teucrii* Ellis & Kellerm.  
On *Teucrium canadense* L., Stillwater, Sept. 1940, No. 2230.

OKLAHOMA A. & M. COLLEGE,  
STILLWATER.

# FUNGI OF SOUTHERN CALIFORNIA. I

PAUL MARSHALL REA

(WITH 3 FIGURES)

Southern California is of interest mycologically for several reasons. Since it is the southwestern corner of the United States, a knowledge of its fungus flora is essential to a picture of the distribution of fungi in this country. Having all the life zones from Lower Sonoran to Transition, it produces cosmopolitan subtropical species as well as those of circumpolar distribution. A number of species described from here about forty years ago have not since been reported and will be of interest as they are re-collected and their validity determined.

This paper is planned as the first of a series on the mycoflora, especially the higher fungi, of this region.

BATTARREA PERS. 1801<sup>1</sup>

This is a cosmopolitan genus, found in all continents, but with individual plants usually rare and widely dispersed. Seldom have collections from one region been adequate to show the range of variation, and most of the proposed species have been based on single plants or collections. It is generally agreed that many of these are synonyms, and Hollos (6) believed there is only one highly variable species, while Lloyd (7. 7: 1175) concluded that there are two, *B. phalloides* and *B. Digueti*. Others recognize at least one more but disagree about its taxonomy. Although these

<sup>1</sup> The writer is indebted to the Santa Barbara Museum of Natural History for the privilege of reporting on specimens of *Battarrea* in its herbarium, to Dr. F. J. Seaver for a photograph and a pinch of the gleba of the types of *B. Griffithsii* in the N. Y. Botanical Garden, to Mr. J. A. Stevenson for gleba and notes on dehiscence of specimens of the genus in the Lloyd herbarium, to Dr. A. H. Smith for the photograph and opportunity to study the Texas specimens of *B. Digueti* in the Univ. of Michigan herbarium, and to Miss E. E. Morse for criticisms and suggestions. The photomicrograph for figure 3 was made by Miss Florence Connolly of the Sansum Clinic, and the photograph for figure 2A by Mr. E. Z. Rett. Mrs. Rea made the drawing for figure 1 and has participated in all the field and laboratory work.

plants have been known in England since 1784 and in this country since the Oregon collection of the Wilkes Exploring Expedition, 1838-42 (4), the details of their structure have been little known until recently because the significant stages of development are hypogean and difficult of access.

The basis of this study, apart from comparative material, is a series of 25 specimens from southern California, including 5 from the coastal region near Santa Barbara and 18 from the Mojave desert about ninety miles to the east. It appears to include most if not all the described forms of *Battarrea*. It affords new information on the structure of the elaters, confirms *B. Digueti* as a valid species with *B. Griffithsii* as a synonym, and contributes to, but does not solve, the problem of the limits of variation in *B. phalloides*.

The characters of the genus, as now understood, are as follows:

Sporophores at first hypogean, enclosed in a universal veil or exoperidium which dehisces circumscissilely or apically, the basal portion persisting as a volval cup at the base of the stipe. Stipe clothed with scales, hollow, with a slender axial cord in the cavity, elongating rapidly to lift the endoperidium at its apex above the ground. Endoperidium convex above, concave below, dehiscing circumscissilely and shedding the upper half, or dehiscing by multiple pores with the upper half long persistent. Gleba pulverulent at maturity, comprising globose ornamented spores; elaters with annular or spiral thickenings; and capillitium of tubular threads or amorphous strands arising from the floor of the endoperidium and forming a spongy tissue. Basidia forming an elementary hymenium lining cavities or logettes, clavate, producing four spores apically on sterigmata, not persisting at maturity. As far as is now known, the presence of elaters distinguishes *Battarrea* from all other fungi.

The putative species, about 16, may be grouped as follows:

Dehiscence of both peridia circumscissile; elaters up to 80, rarely 100  $\mu$  long.....*B. phalloides* group  
Dehiscence of exoperidium apical, of endoperidium by multiple pores; the longer elaters typically 100-200 +  $\mu$  long.....*B. Digueti*

The *Battarrea phalloides* group.

The plants with circumscissile dehiscence assume two principal forms and the taxonomic problem is whether these represent two species or variations of one. The traditional distinctions are:

Plants of slender habit, with narrow scales on the stipe. Represented by *B. phalloides* (Dicks.) Pers. (the type species).

Plants usually more robust, with broad, ribbon-like scales. Represented by *B. Stevenii* (Libos.) Fr.

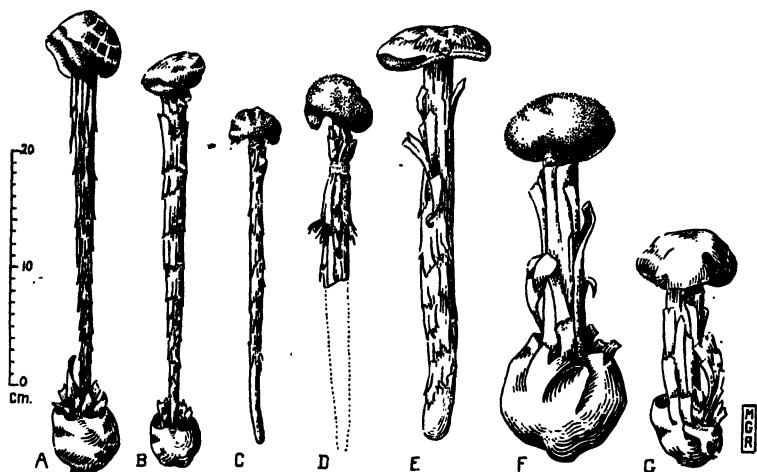


FIG. 1. Southern California specimens showing variation in the *Battarreca phalloides* group. Drawings were necessary because the specimens were not all available for photographing. A, B, specimens from the Mojave desert (Herb. Paul & Marian Rea 1011). C, D, after photographs in Lloyd (7. 1: Aus.: pl. 28); C being Lloyd's fig. 1, a specimen collected in 1902 near Hueneme lighthouse, and D his fig. 2, a specimen collected in 1902 in the Santa Ynez Mts. E, specimen collected in 1939 by M. C. Richter in Mission Canyon, Santa Barbara (Rea 204). F, after water-color sketch by Marian Rea of specimen collected in Jan., 1938, near Hendry's beach by Santa Barbara Mus. Nat. Hist., not preserved because of its strong odor. G, specimen collected in Oct. 1938, from same locality and probably from same mycelium as F (Herb. S. B. Mus. Nat. Hist.).

The bearing of our southern California plants on this question is sufficiently evident in figure 1 to require only a few supplementary observations. At one end of the series, some of the desert plants (FIG. 1 A) agree perfectly with the typical English *B. phalloides* in size, slender habit, fine scales, and other characters. At the other end, two plants from the coast (FIG. 1 F, G) agree equally well with *B. Stevenii*. All the 17 desert plants, taken at the same locality and date, have the slender habit, but some have broader scales (FIG. 1 B) and these two types of scales often intergrade on the same stipe. The remaining figures (1 C, D, E) are from

plants collected in or near Santa Barbara and show further intermediate variations. Our conclusion is that, however different in the extremes, this series intergrades, and *B. Stevenii* should become a synonym of *B. phalloides* insofar as concerns the characters under consideration.

This is not the end of the matter, however, for Maublanc & Malençon (10) have put it in a new light by maintaining that the important distinction is the presence of abundant gelatinous material within the universal veil in the egg stage of *B. phalloides* and its entire absence in the second form. They cite observations of the dry volva by previous authors in plants referred to *B. Stevenii*, which they consider identical with *B. Guicciardiniana*, on which their principal work was done. They admit the priority of the former name but, because the type specimen lacked the volva, so important in their view, they chose to use the name *B. Guicciardiniana* Ces. They interpret *B. Gaudichaudii* Mont. as very close, but distinct by reason of a difference in color of spores. They are of the opinion that most of the other described species will fall into one or the other of the two principal types of this group when they are better known. They cite Mattiolo, whose work we have not seen, as adopting the name *B. Gaudichaudii*, with *B. Stevenii* and *B. Guicciardiniana* as synonyms.

Furthermore, they maintain that *B. phalloides*, with the gelatinous volva, is confined to northern, cooler, more humid regions, which they outline; while the *B. Stevenii*-*Guicciardiniana*-*Gaudichaudii* group, with dry volva, is confined to southern, subtropical, hot, dry regions.

Cunningham (3) reports that only plants with a dry volva are found in Australia, and adopts the name *B. Stevenii*. Of the dry volva he says: "It is this feature alone which separates these two closely related species" (*B. phalloides* and *B. Stevenii*).

Whether this sole feature, if substantiated, would form an acceptable specific distinction may be debated, but it is certainly an awkward one because it seems to require observation of the egg stage before any specimen can be specifically determined. One aspect of our series is noteworthy in this connection, viz., that it is the plants from the coast, in a very mild and equable climate, that conform in a striking manner with the traditional characters

of *B. Stevenii*, while those from the Mojave desert are the ones that conform with the traditional characters of *B. phalloides*. The latter come up in summer after occasional rains that are followed by temperatures often much over 100° F. This difference in habitat appears to be diametrically opposed to the theory of Maublanc & Malençon.

Pending further information on this troublesome problem of the dry or gelatinous egg, we continue to interpret our specimens as variations of one species which we designate, for the present at least, as *B. phalloides*. If and when they prove not to be that species, the relative merits of *B. Stevenii*, *B. Guicciardiniana*, and *B. Gaudichaudii* may be debated.

*Battarreia Digueti* Pat. & Har. (11) 1896.

*B. Griffithsii* Und. apud White (16) 1901.

*B. Digueti* form *minor* Lloyd (7. 7: 1175) 1923.

The distinctive characters of this species are: apical dehiscence of the exoperidium, which consequently leaves no volval patch on the endoperidium; dehiscence of the endoperidium by multiple pores; and greater length of the elaters.

The marked difference in the method of dehiscence might afford a basis for erecting a new genus for this plant, but to do so would in our opinion obscure its identity with *Battarreia* in other respects, viz., gleba with similar spores, elaters, and capillitium, and endoperidium convex above and concave below, borne on the apex of a long stipe which is hollow, with an axial cord in the cavity, clothed externally with scales that vary from needle-like to ribbon-like as in the *B. phalloides* group, and provided with a volval cup at the base.

The type collection was made in "Basse-Californie," Mexico, and the authors clearly described and illustrated the dehiscence by multiple pores and noted the length of the elaters as 100–150  $\mu$ .

The next collection was made by David Griffiths in 1900, at Tucson, Arizona, and was distributed in part to the New York Botanical Garden, where it became the type of *B. Griffithsii* Und.; in part to Lloyd, who published it (7. 1: 90) erroneously as from New Mexico; and in part to Hollos (6: 40). The original de-

scription of *B. Griffithsii* is misleading in that it says of the endoperidium: "lower part flat, showing the line of dehiscence distinctly," and the accompanying illustration "Peridium showing method of dehiscence" is a pen drawing showing a circumscissile crack, and no pores. In 1906, Lloyd (7. 2: Tyl. 7) said of *B. Digueti*: "This plant differs from all other known species in the *persistent* peridium. It has been collected in Lower California and in Arizona and was described by Miss White as *Battarrea Griffithsii*." But Lloyd did not at that time appreciate the significance of the multiple pores in *B. Digueti*, believing that circumscissile dehiscence was merely delayed, and his photographs of the types of *B. Digueti* and *B. Griffithsii* (l. c. pl. 75) are so taken that they show little if any sign of the pores. Hence, his synonymy of these two species is not conclusive. It requires evidence that the original description was inaccurate and that the plant actually has multiple pores. It is therefore a satisfaction to publish a photograph (FIG. 2 C) of the types of *B. Griffithsii* kindly furnished by Dr. Seaver. Although a part of the margin of one specimen has disintegrated, this is not to be confused with circumscissile dehiscence and both specimens clearly show multiple pores. On this evidence, *B. Griffithsii* Und. becomes a synonym of *B. Digueti* Pat. & Har., a reduction confirmed by our finding elaters up to  $138\ \mu$  long in the types of the former.

In 1909, Lloyd (7. 3: L25: 3) reported "a number of fine specimens, every one with peridium attached, which is *the characteristic* of this species, if it has any" collected by Dr. F. E. Lloyd at Zacatecas, Mexico. Again Lloyd failed to mention multiple pores, but Mr. J. A. Stevenson writes that these are present, and in the gleba we find elaters  $114\ \mu$  long.

In 1921, Ivan M. Johnston made two collections from the Gulf of California region of Mexico, which were reported and illustrated by Lloyd (7. 7: 1174-5, pl. 228, f. 2334-5). The photographs show multiple pores, and it was this collection that finally convinced Lloyd that there are two real species of *Battarrea*. He says: "The endoperidium remains entire at least in all specimens I have seen and dehisces as shown by these specimens (Fig. 2334) by small circular, irregular mouths. That the upper half does finally dehiscence by a circular cleavage, or breaks irregularly, and

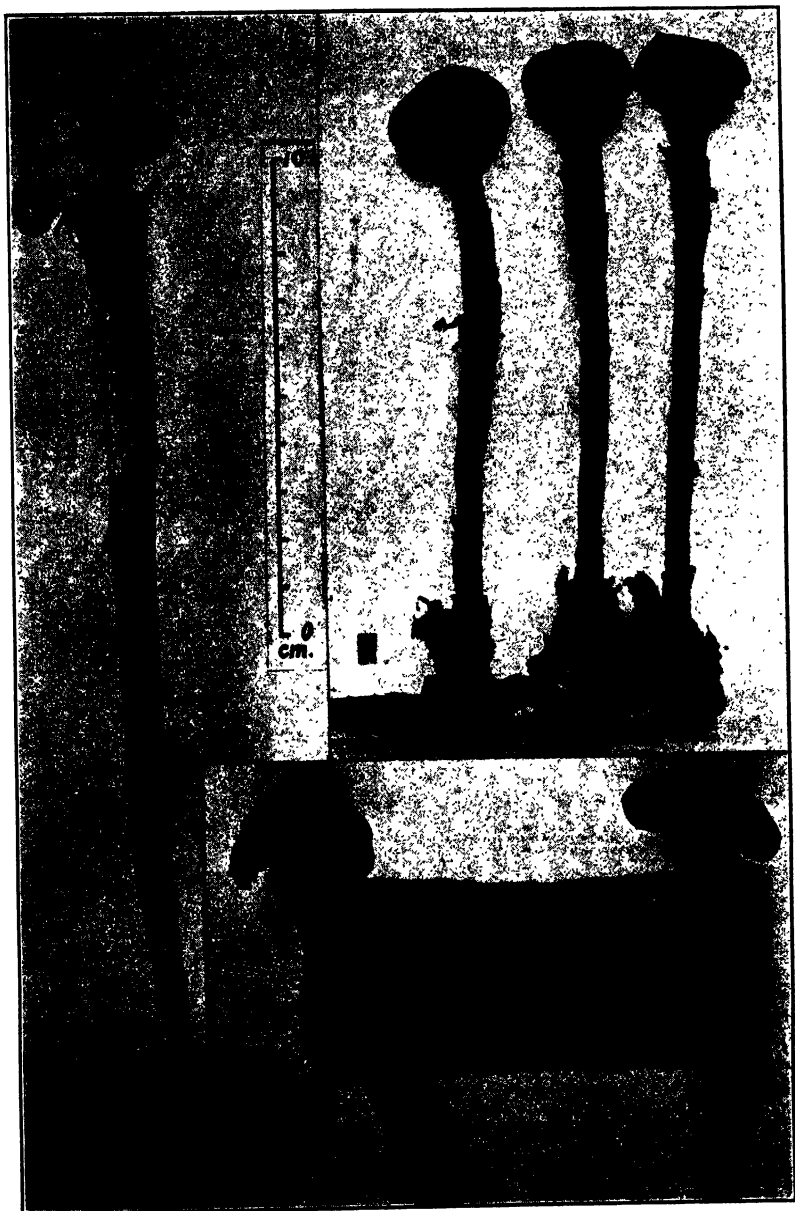


FIG. 2. *Battarrea Digueti* Pat. & Har.: *A*, from Mojave desert, California (Herb. Santa Barbara Mus. Nat. Hist.); *B*, from Hidalgo County, Texas (Herb. Univ. Mich.); *C*, from Tucson, Arizona (type of *B. Griffithsii* Und. in Herb. N. Y. Bot. Gard.).



falls away is probable, but I have no evidence of it on any specimen I have seen." One of the Johnston specimens, a slender plant but over 20 cm. tall, was described by Lloyd as form *minor* with the comment: "Surely the same plant as the previous but a small form." We find elaters up to  $240\ \mu$  long in the larger specimen and up to  $138\ \mu$  in the smaller, both with rather abundant branching.

In 1933, E. U. Clover collected in Hidalgo County, Texas, a very interesting series of four plants (FIG. 2 B), now in the herbarium of the University of Michigan. They are the smallest yet reported, show the pores well, and have elaters up to  $156\ \mu$  long.

In 1938, on the edge of the Mojave desert about 17 miles from Palmdale, California, Mrs. Verna Wright collected a typical specimen (FIG. 2 A) but without the volva. This is in the herbarium of the Santa Barbara Museum of Natural History. It has the characteristic multiple pores and elaters up to  $240\ \mu$  long, including several of the best examples of branching we have yet found (FIG. 3).

The validity of this species is established by the constant occurrence of multiple pores in a long-persistent endoperidium, and is strengthened by the presence in every collection of elaters exceeding in length any yet reported in other species.

#### THE GLEBA IN BATTARREA

It is generally agreed that the gleba is essentially the same in all plants of this genus. Little was known of its development until a locality was found in Tunis where the plants came up in quantity each year and Maublanc & Malençon (10) succeeded in obtaining all stages from eggs to maturity. Their investigation traced the early formation of cavities or logettes lined with basidia that mature in succession and produce apically four spores on sterigmata. Each basidium withers when it has discharged its spores, and after expansion of the plant no more basidia are formed. The basidia arise from interwoven hyphae of a subhymenium, the ultimate fate of which was not traced. Each logette has an outer wall of encircling hyphae which is said to persist as a delicate membrane around a cluster of spores. The tramal hyphae between the logettes arise from the floor of the endoperidium and persist as the capillitium of the mature gleba.

*Mature capillitium.* In some specimens this is in the form of very long threads up to  $8\ \mu$  thick, tapering gradually to slender ends, rarely with short branches, tubular, with rather thick walls, rarely if ever septate. In other specimens the threads are degenerate, flattened, no longer showing a cavity, tending to fray out into vague filaments. Transitions between these two states are found.



FIG. 3. Elaters in *Battarrea Digueti*, showing unusual length and branching. The micrometer scale is  $120\ \mu$  long and its smallest divisions represent  $1.2\ \mu$ .

*Elaters.* These peculiar elements of the gleba are very suggestive of the structures of the same name in the Hepatici and in the Myxomycetes (Trichiales). Their annular or spiral thickenings are internal, the delicate outer membrane being traceable over them. They have frequently been described as closed cells, but most of them are actually broken at one or both ends. They often have constrictions that suggest incipient breaks (FIG. 3, lower left), and in one instance an elater was seen to break as it moved in a

current of the mounting fluid. Elaters with short branches may be found occasionally in almost any specimen. These observations are a strong indication that the elaters of the mature gleba are fragments of a structure that was once more nearly continuous. Actual demonstration of this is found in *B. Digueti*. Not only do its elaters attain a length of  $240\ \mu$  or more, but they sometimes show long and multiple branching. Figure 3 is a photomicrograph of an unusually fine example, yet even this complex structure is itself only a fragment, for three of the ends are broken (the fourth being hidden by spores).

The origin of the elaters is not known, but it is now evident that it must be sought in some extensive, branching tissue, and the time of formation has been fixed by Maublanc & Malençon (l. c.). They find that elaters appear among the spores suddenly and fully formed at about the time of expansion of the plant, while in slightly younger specimens they find no sign of them. They speculate that elaters correspond to degenerate spores produced by basidia at the moment when, impoverished by normal spore production, they are about to wither. While this might be a plausible hypothesis for the short fragments conceived as closed cells, it seems entirely inadequate for the extensive structures that are now the crux of the problem.

The most likely place to seek the origin of elaters is the subhymenium, which is the only tissue whose ultimate fate has not been traced. Here are hyphae of the requisite length and it is conceivable that, after production and withering of basidia has been completed, the substance of these hyphae may be used in forming annular and spiral thickenings of the walls. This would produce such long and complex elaters as we have found and, by fragmentation, the shorter pieces more commonly seen. It would explain the disappearance of the subhymenium as such, and the sudden emergence of elaters among the spores. Perhaps W. G. Smith (13) actually saw something of this process. He says: "The spiral thread within the vessel is clearly formed from a differentiation of the contents, as I have seen them in every stage. . . ." His figure illustrates these stages most interestingly. It differs from our own concept only in having the elaters produced as erect outgrowths from the subhymenium, while we think of

them as more probably a direct transformation of the horizontal hyphae themselves.

With respect to the reliability of the length of the longer elater fragments as a specific distinction, a few comments are in order. Our measurements for the *B. phalloides* group confirm those of previous authors, the maximum length in most specimens being 63–80  $\mu$  as reported by C. Rea (12: 53), very rarely up to 100  $\mu$  as reported by Höllos (6: 40). Every collection of *B. Digueti*, on the contrary, has them in excess of 100  $\mu$ , usually by a large margin. It is not at all impossible that some overlapping may be found by further search, but it is quite certain that the frequency of elaters over 100  $\mu$  long and the great length of some of them will prove a distinctive character of *B. Digueti*. If the elater is a little stronger in one species than in another it would explain why the length of the fragments is a specific character.

*Spores.* The spores are essentially the same in all specimens of *Battarreia* we have studied. They are globose, often apiculate, usually (4)5–6(7)  $\mu$  in diameter. Giant spores of more irregular shape and up to  $8.4 \times 7.2 \mu$  are rather common in one of Lloyd's *B. Digueti* from Zacatecas, and similar giants up to  $9.6 \times 7.2 \mu$  in one of his *B. phalloides* from Santa Ana, California. The ornamentation is very much like that in *Ganoderma*, and has been variously interpreted as warted, reticulated, or perforate.

SANTA BARBARA, CALIFORNIA.

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# MONILINIA AMELANCHIERIS

EDWIN E. HONEY

In a paper<sup>1</sup> giving brief preliminary notes on certain North American monilioid species of *Sclerotinia*, Reade (1908) described the conidial stage of a new species pathogenic on hosts designated by him as *Amelanchier canadensis* (L.) Medic. and *A. Botryapium* (L. F.) D C. collected during June of 1907 at Junus and Malloryville near Ithaca, New York. The perfect stage was not known to him, however, he designated it as "*Sclerotinia* (*Stromatinia*) *Amelanchieris* Reade n. f."

The purpose of the present note is to offer a brief technical description of the perfect stage together with the conidial stage as found by the writer in the above mentioned stations and neighboring localities in New York State pending the appearance of a more extended paper that has been prepared for publication.

The apothecial stage of Reade's *Monilia Amelanchieris* has been familiar to the writer since the spring of 1921 when on a collecting trip under the guidance of Professor H. H. Whetzel. For several subsequent springs collections of the apothecial and conidial stages of this fungus were made on trips taken in the vicinity of Ithaca, in the Finger Lakes Region of New York State. Brief reference has been made to this species in a previous paper.<sup>2</sup> In the present paper the writer includes this species within the genus *Monilinia* and describes for the first time the apothecial stage. Measurements used here are for fresh living material.

## **Monilinia Amelanchieris** (Reade) comb. nov.<sup>3</sup>

*Entostromata* in dejectis perhiemantibus et mumificatis fructibus formata, quorum formam exteriorem nonnumquam subcuticula simulant, composita de

<sup>1</sup> Reade, J. M. *Sclerotinia* (*Stromatinia*) *Amelanchieris* Reade n. sp. In Preliminary notes on some species of *Sclerotinia*. Ann. Myc. 6: 114. 1908.

<sup>2</sup> Honey, E. E. North American species of *Monilinia* I. Occurrence, grouping, and life histories. Am. Jour. Bot. 23: 101, 102, 105, 106. 1936.

<sup>3</sup> The writer wishes to acknowledge his indebtedness to Dr. J. P. Hieronimus of the University of Wisconsin for his generous assistance in translating the species diagnosis to Latin.

medullis densimuratis hyphalibus, quae plus minusve cum cellis hospitis necroticis collapsis intermixtae sunt, cortice nigro tecta, minus conspicua sed typo similia aliis generis speciebus; *spermatia* (microconidia) parva, 2.5–3.5  $\mu$  diam., sphaerica, plerumque maculam centralem refringentem habentia, fructibus mumificatis adjuncta qui entostromata habent, vel immediate vel spermatophoris (microconidiophoris) brevibus nascentia, in utrovis polo vel ambis simul ascosporarum quae in apotheciis veteribus manent, in myceliis vel in conidiis (macroconidiis), etiam in aquae vel aquaeductilis vel destillatae culturis inventa, in agari nutrienti abunde procreata; *apothecia* 1–3, plerumque 1, orientia parva aculeata fundamenta ab entostromatibus in parvis mumificatis fructibus, saepe ex fine florali sed interdum ex quovis loco fructus mumificati, adulta ad 4 cm. in altitudine, cyathoidea, pallida; *stipes* laevis et gracilis, cylindraceus, nonnihil inferne attenuatus, 1 mm. vel minus in latitudine, 3.5–4 cm. in longitudine, ex parallelis hyphis generi communibus compositus, superne disco concolor, inferne etiam atratior quam light seal brown (R.)<sup>4</sup> vel Van Dyke brown (R.); *discus* primo clausus, mox aperiens, expandens, postea cyathoideus vel infundibuliformis, 1.5–9 mm. diam., plerumque 4–5 mm., margo aliquantum crassus, colore varians ex cinnamon brown (R.) per Dresden brown (R.) and Snuff brown (R.) et Saccardo's umber (R.); *asci* cylindracei-clavati, 117.5–188.0  $\times$  6–13  $\mu$ , plerumque 150  $\times$  9  $\mu$ , cum apice rotundo incrassato qui poro perforatus est cuius claudens substantia iodo caerulescit, octospori; *ascosporae* saepe oblique et monostichis in parte superiore asci, ellipsoideae cum rotundis apicibus, hyalinae, continuae, lucidae, vel cum una macula refrigente ad untrumque sporae finem, 10–15.5  $\times$  5.5–9.0  $\mu$ , plerumque 12–13  $\times$  6.5–7.5  $\mu$ ; *paraphyses* subabundantes, filiformes sed superne subclavatae, apice subapiculato potius quam rotundato, paulatim ad basem attenuatae, ex apice qui est 3.5–5.5  $\mu$  diam., plerumque sine ramulis, non septatae vel cum paucis septis saepe ad basem positae, hyalinae; *ectostromata* sub epidermide foliorum sparsorum, in floribus et fasciculis fructuum teneris enata, quibus ruptis effusa fructificatio conidialis efficitur, praesertim in regionibus necroticis in pagina superiore foliorum et calycis fructuum immaturorum, tegmen albescens vel cinereum et pulverulentum efficiens; *conidia* (*Monilia Amelanchieris* Reade) limoniformia, hyalina, continua, 14–23  $\times$  10–14  $\mu$ , in longis dicto-vel trichotome ramosis catenulis, nascentia cum matura sunt, disjunctores, graciles et fusiformes, 2–3  $\mu$  longi, conidia intra catenulas dividunt.

HAB.: Apothecia nuntiantur in mumificatis perhiemantibus fructibus plantae palustris "shad bush," "Juneberry," vel "service berry" (*Amelanchier intermedia* Spach.), humi in foliis putrescentibus in locis humidis, mense Aprili exeunte et Maio ineunte; conidia nuntiantur pathogenica in *Amelanchieri intermedia* Spach., *Amelanchieri canadiensis* Med. (*Amelanchieri Botryapium* Borkh.), *Amelanchieri oblongifolia* Roem. et *Amelanchieris* spp., primo existens in hospitibus tempore florescentiae vel paulo post, deleto communis florum, fructum immaturorum, foliorum, et incrementi horni, mense Junio ineunte vel mediante, in regione Finger Lakes, New York.

<sup>4</sup> Ridgway, R. Color standards and color nomenclature, 44 pp. 53 col. pl. Washington, D. C. 1912.

*Entostroma* formed within fallen overwintered mummied fruits whose outer shape it may simulate more or less beneath the cuticle, composed of thick-walled hyphal medulla intermingled to varying degrees with the necrotic collapsed host cells, with a black protective rind; less conspicuous but of similar type to that of other species of the genus.

*Spermatia* (microconidia) small  $2.5\text{--}3.5\ \mu$  in diameter, spherical, hyaline, commonly exhibiting a central refractive spot, associated with mummied fruits containing entostroma, produced at one or both poles of ascospores remaining in old apothecia, on conidia (macroconidia) or on mycelia directly or on single or clustered short flask-shaped spermatophores (microconidiophores), also found in tap or distilled water and nutrient agar cultures.

*Apothecia* one to three, generally one, arising as small pointed fundaments from entostroma developed within small mummied fruits which may be scarcely more than in the late blossom stage up to medium sized fruits, commonly from the blossom end but may appear from any place on the mummied fruit, at maturity up to 4 cm. in height, cyathoid, light colored; *stipe* smooth, slender, cylindrical, tapering more or less below, up to 1 mm. in breadth, up to 3.5–4 cm. in length, composed of parallel hyphae typical of the genus, upper part of same color as the disc, base darker, even darker than Light Seal brown (R.) or Van Dyke brown (R.); *disc* at first closed, soon opening, expanding, becoming cyathoid, or somewhat infundibuliform, from 1.5 mm.-9 mm. in diameter averaging 4–5 mm., margin moderately thick, color somewhat variable from a cinnamon-brown (R.) through Dresden Brown (R.) to Snuff Brown (R.) and Saccardo's umber (R.). Asci cylindrical-clavate  $117.5\text{--}188 \times 6\text{--}13\ \mu$ , most averaging  $150 \times 9\ \mu$ , with a rounded thickened apex which is perforated by a pore, the closing substance of which stains blue with iodine, eight-spored; *ascospores*, commonly arranged obliquely-uniseriately in the upper end of the ascus, ellipsoidal with rounded ends, hyaline, continuous, clear or with a single refractive spot toward each end of the spore and measuring  $10\text{--}15.5 \times 5.5\text{--}9\ \mu$ , usually  $12\text{--}13 \times 6.5\text{--}7.5\ \mu$ ; *paraphyses* moderately abundant, threadlike but slightly swollen toward the upper portion, the extreme tip inclined to be slightly pointed rather than rounded, gradually tapering from the tip which is from  $3.3\text{--}5.5\ \mu$  in diameter, usually unbranched, non-septate or with few septa frequently placed toward the base, hyaline.

*Ectostroma* developed beneath the epidermis of scattered leaves, in blossoms and young fruit clusters rupturing the same and giving rise to an effuse conidial fructification particularly on necrotic areas on the upper surface of leaves and on the calyx-cup of immature fruits, forming a whitish or ash-gray pulverulent coating.



*Conidia* (*Monilia Amelanchieris* Reade) limoniform, hyaline, continuous,  $14-23 \times 10-14 \mu$  borne in long dichotomously branched chains, at maturity slender fusiform disjunctors  $2-3 \mu$  long separate the conidia within the chains.

Hosts: Apothecial stage reported on the mummied overwintered fruits of the swamp shad bush, Juneberry, or service berry, *Amelanchier intermedia* Spach., on the ground in the leaf mold in moist places during the last half of April and the first half of May. Conidial stage reported pathogenic on *Amelanchier intermedia* Spach., *A. canadensis* Med. (*A. Botryapium* Borkh.), *A. oblongifolia* Roem. and *Amelanchier* spp., first appearing upon the suspects at the time of bloom or shortly after, common and destructive to the blossoms, young fruits, leaves, and current years growth, during the early and middle part of June in the Finger Lakes Region, of New York State.

DEPT. OF PLANT PATHOLOGY,  
UNIVERSITY OF WISCONSIN,  
MADISON, WISCONSIN.

## NOTES ON FUNGI PREVIOUSLY UNREPORTED FROM MISSOURI

J. B. ROUTIEN

During 1941, many collections<sup>1</sup> of fungi were made by the author in certain parts of Missouri. Those which have been identified with certainty and which are new for the state are discussed here. Remarks are given about those of special interest or which varied somewhat from the descriptions; the others are listed at the end of the paper. Duplicates of most collections are in the Herbarium of the University of Missouri.

*CORDYCEPS MILITARIS* Link. Well developed specimens were found on larvae of a moth of the family Notodontidae in grassy soil in the woods after about a week of intermittent rains. Columbia.

*LEOTIA LUBRICA* forma *STEVENSONI* (Berk. & Br.) Mass. Specimens were found at various times from late September to late October usually in rather rocky soil in oak woods. In all cases the color of the specimens placed them in this form rather than in the species proper. Bagnell Dam, Salem, Mineola.

*CRONARTIUM QUERCUM* (Berk.) Miyabe. The telial stage has been reported by Maneval (The University of Missouri Studies 12 (3): 1-150. 1937.) on leaves of oaks in Missouri. The aecial stage was found twice in May on young saplings of *Pinus echinata* Mill. In both cases the sapling was almost entirely girdled. The aecial stage on this pine has also been reported by Arthur (Manual of the rusts in United States and Canada. 1934.) from Arkansas and Tennessee. Shannon County, Texas County.

*PUCCINIA VIOLAE* (Schum.) DC. This rust was reported by the author (Plant Disease Reporter 25 (8): 225-229. 1941.) in 1941 to occur on *Hybanthus concolor* (Forster) Spreng. It was

<sup>1</sup> The collections were made possible by a grant from the University Research Council, University of Missouri.

found again on this host on plants growing in a certain area at Meramec State Park. The spore characters agreed with the description of the species; this confirms the earlier report that *H. concolor* is another host for *P. Violae*.

All plants in the colony of *H. concolor* were heavily infected. The lowermost leaves were almost yellow because of the severity of the attack; younger leaves were lightly infected, and the youngest leaves on the date of collection (May 24, 1941), as well as others formed later, remained free of the disease. By June 15, 1941, many infected leaves had fallen or had become withered and curled.

Not infrequently white aecia were found intermingled with the normal orange ones. Sometimes the aecia on one side of a cluster were orange and those composing the rest of the cluster were white. Spores from the white aecia measured the same and had the same markings as did those from orange aecia. Sullivan.

*HYDNUM FULIGINEO-VIOLACEUM* Kalch. In most characters these plants fitted Banker's (Mem. Torrey Club 12: 99-194. 1906.) description of the species. They differed in the following points: presence of a red juice in young broken caps; lack of scaliness of the cap; absence of a radicating base; presence of a violet tint in the cap. Since Banker (Mycologia 5: 12-17. 1913.) finally referred his collection to a new species, *Sarcodon radicans* Banker, and since the Missouri plants agree with the description of *H. fuligineo-violaceum*, it seems likely that this collection represents Kalchbrenner's plants. Eminence.

*CLAUDOPUS DEPLUENS* Fries. In all respects but spore size and shape the specimens agreed with Kauffman's (The Agaricaceae of Michigan, 1918.) description. He lists the spores as "7-10  $\times$  6-7.5 micr.," whereas these plants' spores were 8.5-10  $\mu$  and spherical. Eminence.

*CLITOCYBE LACCATA* var. *STRIATULATA* Peck. Two collections of this plant macroscopically fitted the description well. In one collection, however, the spores were 8.5-10  $\mu$  in diameter rather than 9-11, as Kauffman gives, and in the other collection the spores were noticeably smaller—6-7  $\mu$  in diameter. In spite of these differences the specimens could be referred only to *C. laccata*

var. *striatulata*. Common and widespread after rains. Winona, Kingdom City.

*CLITOPILUS WOODIANUS* Peck. Specimens of this species that Kauffman found to be rare in Michigan were found once on leaf mold after prolonged rain. Spores were  $8.5 \times 7\mu$  rather than 7 micr. in diameter as Kauffman states. Winona.

*COPRINUS PLICATILIS* Fries. Found in two localities on dead grass leaves in woods. Spores were  $12-15.5 \times 9-10.5\mu$ , whereas Kauffman gives " $10-12 \times 7.5$  to  $8.5 \times 5-6$  micr." Mineola.

*CORTINARIUS MICHIGANENSIS* Kauff. A number of specimens of varying stages of development were found in leaf mold and rocky soil in a small ravine in oak woods. The caps were not as large as Kauffman's plants (6 cm. wide as compared with 8-14 cm.) and the gills were not serratulate. The spores were slightly different from Kauffman's description:  $8-9$  (rarely 10)  $\times 5-6\mu$  rather than  $8-10.5 \times 4.5-5.5$  micr. In spite of these differences the specimens seemed best to fit this species. Bagnell Dam.

*ECCILIA PENTAGONOSPORA* Atk. A number of plants that best fitted the description of this species were found on soil in oak woods after several days of rainfall. The plants differed from Kauffman's plants in that the caps were browner than "steel-gray" and were not "appressed-scurfy." The spores were  $8.5-10 \times 7-10\mu$ , whereas Kauffman gives " $7-9.5$  micr." Winona.

*LACTARIUS DELICIOSUS* Fries. One collection of this species was made in pine-oak leaf mold after prolonged rainfall. Kauffman states that the taste is "mild" and Burlingham (N. Am. Flora 9: 162-426. 1910-1916.) states that it is "somewhat acrid," but these specimens were strongly acrid. In all other characters the plants were typical. One item not mentioned in the descriptions is that twisted, copper-orange hyphae measuring usually  $60 \times 5\mu$  arose from a mass of copper-orange, coiled hyphae in the trama and pushed to the surface of the hymenium. Eminence.

*LACTARIUS PERGAMENUS* Fries. Two collections of this plant were made. They agreed well with the description except for the following: Burlingham gives the spore characteristics as " $6 \times 8\mu$ , minutely echinulate," but the spores of these plants were smooth and measured in the two collections  $7-8 \times 6-6.5\mu$  and  $7.5-8.5 \times 5-6\mu$ . Salem.

*LEPIOTA CLYPEOLARIA* Fries. Found twice on leaf mold in oak woods. The plants agreed well with Kauffman's plants except in regard to spore size. Kauffman gives " $10-16 \times 4-6$  micr., very variable in size"; the Missouri plants were  $12-15 \times 5-7 \mu$ . Mineola, Salem.

*LEPTONIA SETICEPS* Atk. Several specimens of this fungus were found on a decaying oak log in the woods. They were slightly different from Kauffman's description: caps were not over 1.5 cm. wide (Kauffman gives 1-3 cm.); stems were 3-4 cm. long (compared with 1-2 cm.); gill edge was not eroded: cystidia measured  $37-60 \times 15-30 \mu$  (Kauffman states " $50-60 \times 10-15$  micr."). Bagnell Dam.

*OMPHALIA EPICHYSIUM* Fries. Specimens best fitting this species were found on a decaying log in the woods. The plants were somewhat lighter in color than Kauffman states, and the spores measured  $5-6 \times 3.5 \mu$  rather than  $7 \times 4$  as in his description. Columbia.

*PANAEOLUS RETIRUGIS* Fries. The spores of the specimens were  $12-14 \times 7-8.5 \mu$  as compared with Kauffman's measurement of " $15-18 \times 9-11$  micr." On soil in a flower bed recently manured. Columbia.

*PLEUROTUS CORTICATUS* Fries. No sporophores of this fungus were found. However, from black-tipped coremia lining a cavity in the decayed heartwood of a black oak (*Quercus velutina* Lam.) and from rotted wood underlying the coremia pure cultures of a fungus were secured. After growing on a mixture of beech shavings and 4 per cent malt extract for over three months, the fungus produced small sporophores on the gills of which basidiospores developed. These spores measured  $12-17 \times 5-7 \mu$ , were elliptical to oval, often narrowed at one end, obliquely, slightly apiculate, hyaline, smooth. Kaufert (Tech. Bull. 114, U. of Minn. 1936.) reports the mean size of the spores as  $16.05 \pm 1.07 \times 4.8 \pm .222$ . He reports it from Louisiana and Mississippi from decay of young fire-scarred hardwoods and refers to its having been found in the eastern United States. The decay in the Missouri trees was associated with a partially healed branch stub. Willow Springs.

*PSATHYRELLA CRENATA* Fries. A number of specimens, with veil still present, were found on decaying wood and leaves in the woods. The spores were  $12-13.5 \times 7-7.5 \mu$  as compared with Kauffman's measurement of " $10-12.5 \times 6-7$  micr." The infrequent pleurocystidia were cylindrical, tapering slightly at both ends, and usually about  $50 \times 12 \mu$  in size; no cheilocystidia were found. Columbia.

The following fungi new to the state were also collected and identified: *Humarina semiummersa* (Karst.) Seaver. Columbia; *Patella albida* (Schaeff.) Seaver. Columbia; *P. pulcherrima* (Crouan) Seaver. Columbia; *Pilacre faginea* (Fries) Berk. & Br. Columbia; *Clavaria pistillaris* Fries. Miller County, Columbia; *C. byssisseda* Fries. Columbia; *Typhula phacorrhiza* Reichard ex Fries. Columbia; *Hydnum zonatum* (Batsch.) Karst. Salem; *Polyporus circinatus* Fries at base of *Pinus echinata* Mill. Eminence (Overholts reported this only from Wisconsin and Michigan in his monograph in 1915 (Washington Univ. Studies 3: 1-98. 1915.)); *Amanita bisporiger* Atk. Sullivan; *A. spissa* Fries. Columbia; *Amanitopsis volvata* Peck. Eminence; *Cantharellus infundibuliformis* Fries. Salem; *C. tubaeformis* Fries. Eminence, Columbia; *Hygrophorus conicus* Fries. Eminence, Salem, Kingdom City, Columbia; *Hypholoma sublateritium* Fries. Columbia; *Lactarius indigo* Schw. Salem, Eminence; *Lepiota naucina* Fries. Columbia; *Psathyra obtusata* Fries. Columbia; *Boletus albellus* Peck. Salem; *B. luridus* var. *erythropus* Fries. Eminence; *Geaster coronatus* (Schaeff.) Schroet. Salem; *G. fimbriatus* Fries. Columbia; *G. radicans* Berk. & Curt. Columbia; *Lycoperdon fuscum* Bonorden. Eminence; *Scleroderma flavidum* Ellis & Ev. Miller County; *S. geaster* Fries. Columbia; *Tylostoma simulans* Lloyd, well formed by (!) February 15, 1942. Camden County. Reported by Coker and Couch (The Gastromycetes of the Eastern United States and Canada. 1928.) from Ohio, Texas, South Carolina, Florida, Alabama, Iowa and Kansas.

# A NEW GENUS AND NEW SPECIES OF BROWN-SPORED INOPERCULATE DISCOMYCETES FROM PANAMA

H. H. WHETZEL<sup>1</sup>

(WITH 5 FIGURES)

Under date of February 21, 1936, I received a letter from Dr. G. W. Martin of the State University of Iowa in which he says, "Under separate cover I am mailing you some living material of what I take to be a species of *Lambertella*. This developed on some debris collected on Ancon Hill, Balboa, Panama, July 20, 1935. It was put in a moist chamber here on October 28th and shortly thereafter this form began to appear, very sparingly, and only one or two discs at a time."

About a week later the specimen arrived but the already formed apothecia had all rotted away except for the long hair-like stipes on one or two of which the shrivelled receptacle still hung at their tips. The piece of rotten branch was placed in a moist chamber and during the following 6 weeks five or six apothecia developed from previously ungerminated sclerotia scattered over the surface of the substrate (FIG. 3). From these ascospore cultures were obtained which promptly produced the minute black sclerotia in abundance (FIG. 1), but no apothecia developed from them.

Under date of October 15, 1937, I received from Dr. Martin a second collection of what proved to be this same species, this time on pieces of bark taken in the Canal Zone about 2 miles east of Arraijan, August 13, 1937. From apothecia developed from sclerotia on the bark placed in a moist chamber a second isolate of this fungus was obtained. Again from none of the isolates which

<sup>1</sup> *Acknowledgments:* I am greatly indebted to Dr. G. W. Martin and R. F. Cain for sending me the specimens upon which this paper is based, also for critical reading of the manuscript. This investigation was largely financed by a grant from the Penrose Fund of the American Philosophical Society for which I am most grateful.

I made did apothecia develop, although sclerotia were produced abundantly on potato dextrose agar. However, on November 17, 1937, Dr. Martin sent me two isolates which he had made from the 1937 collection. These produced mature apothecia readily and abundantly in about 8 weeks from the date of planting from sclerotia grown on potato dextrose agar (FIG. 4). From these single ascospore isolates were obtained. They all proved to be self sterile but by cross spermatization among themselves and with isolates I had previously made from the 1935 collection, it was readily demonstrated that the fungus is heterothallic.

A comparison of this fungus with *Lambertella corni-marisi* Höhnelt, which at the time I had fruiting in artificial culture, showed clearly that Martin's fungus could not be referred to *Lambertella*. *Lambertella* forms a thin diffuse stroma both in its natural substrate (rotting fruits) as also on potato dextrose agar. It consists of a one-cell-thick dark brown rind surrounding a thin medulla composed of a much branched hyphal network in which are enmeshed the partially digested substrate cells (or agar). The medullary hyphae are thin-walled. The stroma is subcuticular in the natural substrata. Martin's fungus on the other hand produces its stromata in the form of characteristic minute sclerotia hemispherical in shape, and attached firmly to the surface of the wood, bark or agar on which they are formed. Their structure is essentially that of the sclerotia of *Botrytis* species of the *cinerea* type, i.e. a black rind surrounding a loosely interwoven mass of thin walled hyphae embedded in a hyaline gelatinous matrix. Moreover the apothecia of Martin's fungus are very different from those of species of *Lambertella*, the only character they have in common being the colored spores.

As the outstanding characters of this Panamanian discomycete are unlike those of any of the stromatic inoperculates with which I am acquainted, I am presenting it as a new species and the type of a new genus, under the following name:

**Martinia** gen. nov.

*Apothecia* arising one or more from minute hemispherical sclerotia on the surface of the substrate; *receptacle* thin, membranous, shallow saucer shaped, 2 mm. more or less in diam.; *hymenium*



olivaceous to smoky brown when spores are mature; *stipe* long slender, hair-like, brightly colored; *asci* minute, 8-spored; *spores* one-celled, ellipsoid, biguttulate, olive brown. Conidial stage wanting. The genus is named in honor of Dr. G. W. Martin, the collector.

***Martinia panamaensis* sp. nov.**

*Stroma* consisting of minute hemisphaerical black sclerotia 1–2 mm. in diam., scattered over and firmly attached to the surface of the substratum, singly or in small lobed aggregations; rind and medulla as in *Botrytis* of the *cinerea* type.

*Spermatia* known only in culture, globose about  $2\mu$  in diameter, produced from the ends of Indian-club shaped spermatophores borne in naked fasciculate clusters (spermochia) on the aerial mycelium. The species is heterothallic.

*Apothecia* one or two, sometimes more arising from each sclerotium, white, long stipitate, very small, 1–3 mm. diam., thin, membranous, fragile, shallow saucer shaped becoming flat expanded; *hymenium* just before spore discharge olivaceous brown becoming light yellow olive or ecru-olive (R) immediately thereafter; *stipe* unusually long hair-like, reddish brown, lighter above; underside of cup and upper part of stipe coated with white pruinose to woolly hyphal tips; *asci* very small, cylindric above, attenuate below, base abruptly enlarged to form a foot, relatively broad, apex rounded and thickened, pore not sharply defined,  $J + (?)$ , 50 meas.  $32.5\text{--}48.0 \times 4.2\text{--}5.9\mu$ , mode  $39 \times 5\mu$ , av.  $40 \times 5\mu$ ; *ascospores* ellipsoid, slightly flattened on one side, one-celled, smooth, biguttulate, olivaceous or smoky brown when mature, 100 meas.  $4\text{--}5 \times 2\text{--}3\mu$ , mode  $4.2 \times 2.6\mu$ , av.  $4.2 \times 2.5\mu$ ; *paraphyses* apparently simple but actually 2-branched near base, slender, scarcely enlarged toward the tip, not numerous.

On the surface of bark or wood of rotten logs and branches of trees of undetermined identity. Known from two collections, one at Ancon Hill near Balboa, Panama, July 20, 1935, the other near Arraijan, Canal Zone, August 13, 1937. In the case of both these

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FIGS. 1–4. *Martinia panamaensis*: 1, zonate development of sclerotia on potato dextrose agar, nat. size; 2, two of four plantings in the same plate on potato dextrose agar, showing tendency of sclerotia to aggregate and coalesce, nat. size; 3, stick with apothecia developed from sclerotia on the bark in moist chamber, twice nat. size; 4, apothecia developed from sclerotia grown on potato dextrose agar; sclerotia with pieces of the agar cut out and placed on moist sand in a stender dish. Nat. size.



FIGS. 1-4.

collections apothecia were first detected on twigs or bark placed in moist chambers by Dr. Martin in his laboratory some months after the collections were made.

*Herbarium material.* Since our studies on this species were based chiefly on the 1937 collection this is made the type of the genus and of the species, Plant Path. Herb. Cornell Univ. No. 27040. Duplicate material is also preserved in the Herb. Univ. Iowa, Martin's No. 4175. The 1935 collection is deposited in the Plant Path. Herb. Cornell Univ. No. 25246. Duplicate specimens of apothecia grown on potato dextrose agar from the type specimen have been distributed to the following herbaria: Farlow Herb., Harvard Univ.; New York Bot. Gard.; Royal Bot. Gard., Kew, Eng.; British Museum, London; Univ. Toronto, Canada; Mycol. Coll's. Bu. Pl. Ind., Washington, D. C.; Missouri Bot. Gard., St. Louis, Mo. and Univ. Museum, Ann Arbor, Mich.

*Notes.* The outstanding features of *Martinia panamaensis* are: (1) The unusually small asci and ascospores, compared with these organs in related genera having equally small apothecia while the spermatia are of the usual shape and size. (2) The combination of distinct sclerotia and colored ascospores. In the other brown spored genera of the stromatic inoperculates with which I am acquainted the apothecia arise from a diffuse or indeterminate stroma, while in *Martinia* the stromata are determinate, i.e. sclerotia.

The cultural characters of *M. panamaensis* on potato dextrose agar remind one of cultures of *Sclerotinia minor* Jagger. The mycelium is white, forming a thin floccose cottony coating of aerial hyphae in which the bases of the jet black sclerotia are embedded. The sclerotia are, however, somewhat smaller than those of *S. minor* and are typically hemisphaerical in shape except when aggregated and fused as commonly occurs in artificial cultures. These lobed aggregates apparently result from the fusion of individual sclerotia, initials of which arise near one another. They are not to be regarded as single sclerotia. They are firmly attached by their flat bases to the surface of the agar in contrast to the loose superficial attachment of the sclerotia of *S. minor*. Sclerotia develop promptly on potato dextrose agar but apothecia require about 8 weeks from date of planting for their development and maturation. The individual isolated sclerotia usually give rise to

one apothecium, followed later by a second, and rarely by a third one.

In the report of fungi collected on the Mycological Foray at Duchesnay, Quebec, August 23–27, 1938 (*Mycologia* 31: 736), R. F. Cain of the University of Toronto reported an unnamed species which he referred to *Phaeociboria*. My interest in that genus<sup>2</sup> at the time prompted me to write Cain for loan of his material. He very kindly sent me the specimen, saying in the accompanying letter of January 5, 1940, "I am very glad to send you the specimen which I called *Phaeociboria*. Unfortunately

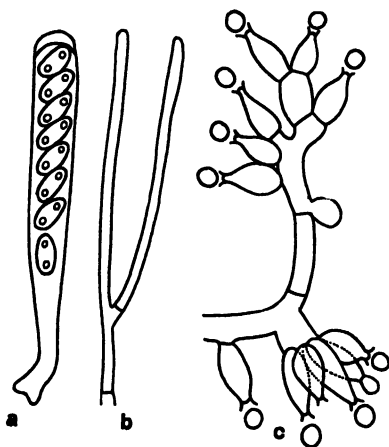


FIG. 5. *Martinia panamaensis*: a, ascus with mature ascospores; b, paraphysis; c, hyphal branch with two spermatidia in early stage of development. All figures  $\times 1025$ .

there are only four apothecia and one of these I mounted in making the original examination. I am sending all the material and notes that I have. I must confess that I have no very sound reason for putting it in the genus *Phaeociboria*, except that it seemed to go there in elementary keys and there seems no other place for it. I hesitated to include the species in the list but it is so distinctive for a disco, and quite different from anything that I have ever seen before. You are entirely welcome to do whatever you think advisable with the material. You may be able to get a culture as

<sup>2</sup> See *Mycologia* 32: 609–620. 1940.

the specimens have not been fumigated. I should have done this when it was fresh but did not get time."

The material Cain sent me consisted of a single ball of rabbit dung, collected along Pine River, Lac St. John, near Quebec City on August 25, 1938 (Cain's No. 6916). On the dung ball placed in a moist chamber in the Botanical Laboratory in Toronto, apothecia developed November 1, 1938. The dung ball bearing 3 of the dried apothecia was glued to the lid of a pill box. Included in the package was a beautifully preserved slide of a fourth apothecium.

Following Cain's suggestion, dilution plates of ascospores from one of the dry apothecia were made in potato dextrose agar on February 2, 1940. The spores germinated 100 per cent (over a year after these apothecia had been dried!). The thalli developed from these ascospores on potato dextrose agar are strikingly like those of *Martinia panamaensis*, and the characters of the dried apothecia and ascospores are essentially identical with that species. However, no apothecia developed from the sclerotia of any of the several cultures thus obtained and which were presumably single spore isolates. Moreover repeated attempts to induce apothecial development by cross spermatization among these isolates and with the + and — isolates of *M. panamaensis* were also unsuccessful. I have, therefore, been unable to compare living apothecia of the Canadian form with those of the Panamanian form. The sclerotia of the former are consistently somewhat larger on the average than those of *M. panamaensis*. This, however, may not be of taxonomic significance and my failure to obtain apothecia by cross spermatization may well have been due to faulty technique.

At first thought the difference in substrata on which the two forms have been found might seem significant. This difference, however, is doubtless of little importance as both are obviously saprophytes, which probably thrive on a variety of dead plant debris, since both grow readily on potato dextrose agar. Their occurrence in such different geographic habitats is more difficult to rationalize. It is conceivable, of course, that the Canadian form may have developed from ascospores brought to the locality by migrating birds from Panama during the spring migration of 1938,

and that the Canadian collection does not represent a species persisting in this northern climate.

In view of the limited knowledge we have at present of this Canadian collection and because of the striking similarity of its morphological and cultural characters to those of the Panamanian specimens I can only assume that the two are specimens of the same species. Further studies on future collections may show them to be varieties or physiologic races of a widely distributed species ranging from the tropics to the cold temperate regions.

Cain's specimen is deposited in the Plant Path. Herb. at Cornell University under the No. 29646.

CORNELL UNIVERSITY,  
ITHACA, N. Y.

## NOTES AND BRIEF ARTICLES

An extensive list of Institutions, Societies and Research Workers in the pure and applied plant sciences in C. and S. America has been prepared by the Editors of *Chronica Botanica*, in coöperation with the Div. of Agriculture of the Office of the Coordinator of Inter-American Affairs, Washington, D. C. It has been published in *Chronica Botanica* Vol. 7, no. 2 and 3 (March and May 1942).

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### CAN WE REPRODUCE SACCARDO'S SYLLOGE FUNGORUM?

The writer has recently found that, if advance subscriptions can be obtained from as few as fifty institutions or individuals, Saccardo's *Sylloge Fungorum* can be made available, in complete sets, at the very moderate cost of about \$30 to \$40 to each subscriber.

The process of reproduction, known as the Readex Microprint, furnishes actual printed pages that can be handled and used in much the same way as the pages of an ordinary book. This permits free and easy consultation of indexes, without the difficulties inherent in microfilm copies, and possibly with less wear and tear than occurs in the handling of actual books.

For the reading of the reproduction, a special patented apparatus is required. This apparatus throws the reduced printed page onto a glass screen at a convenient reading distance and at normal page size. It is already available in some institutions and is certain to become more generally available because of the use being made of it in historical research. Its cost at the present time is \$225.00. This is but half the cost of a good microscope and, with the additional cost of the reproduction of the *Sylloge*, but a small fraction of what an original copy of the *Sylloge* would cost, if it were available at all. And to libraries a substantial discount is, of course, made from the price stated above.

If the reading apparatus were made available in the laboratories of research or teaching departments, it would be found adaptable to many uses other than that of reading microprint. With its

powerful surface illumination and magnification ranging around ten to sixteen diameters, it would supplant the hand lens and dissecting microscope for the superficial examination of minute fruiting bodies, small leaf spots and tiny lesions. With it, the areas of small lesions could be measured accurately, tracings and drawings could be made with ease, and the "scaling" of pathological samples could be done with increased accuracy and with decreased eye strain.

A microprint reproduction of the Sylloge would have many advantages. Individual sets could be made available at small cost to many research workers. Students in mycological courses could be given free access to the work, and libraries would be able to preserve original copies intact and undamaged for posterity.

The writer would be pleased to have the reaction of American mycologists to this proposed reproduction and would especially appreciate assurances that institutions or individuals would definitely subscribe for a microprint set of the Sylloge. It should be noted that a subscription for the reproduction does not entail the purchase simultaneously of the reading apparatus, although eventually subscribing institutions will undoubtedly obtain it for use with this and other reproduced reference works.—L. R. TEHON, 337 Natural Resources Building, Urbana, Illinois.

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#### A NEW GENUS OF THE MYCETOZOA

##### **Elaeomyxa** gen. nov. (oily slime).

Peridiis distinctis, stipitatis vel sessilibus; calce absente; stipae, columello, sporangii muris, vel capillitio cera vel oleo munitis.

Sporangia distinct, stalked or sessile; sporangial wall membranous; capillitium consisting of branching and anastomosing, purplish threads; lime absent, replaced by inclusions, granules, or globules of an oily or waxy substance in the stalk, columella, sporangial wall, or capillitium.

The genus is proposed to include **Elaeomyxa cerifera** (G. Lister) Hagelstein, comb. nov. (*Diachea cerifera* G. Lister, Jour. Bot. 51: 3. 1913.); and **Elaeomyxa miyazakiensis** (Emoto) Hagelstein, comb. nov. (*Diachea miyazakiensis* Emoto, Proc. Imp. Acad. Tokyo 11: 444. 1935).



Type species: *Elaeomyxa miyazakiensis* (Emoto) Hagelstein.

The two forms are remarkable because of the presence of a waxy or oily substance which is unknown in any other species of the Mycetozoa. *E. cerifera* has this waxy material in the stalk, and in specimens from Japan, there is also a waxy collar at the apex of the stalk. European specimens do not have the collar, and may possibly represent another distinct species. Superficially, specimens of *E. cerifera* collected by Meylan in Switzerland, and by Brandza in Moldavia, resemble *Lamproderma columbinum* (Pers.) Rost., and Lister, in early references to the form, regarded it as a phase of that species. Meylan (Bull. Soc. Vaud. Sc. Nat. 58: 82. 1933.) proposed its inclusion in the genus *Diacheopsis* which he had proposed earlier, although on other grounds than the waxy contents. *E. miyazakiensis* was described originally by Emoto as having oil granules in the sporangial wall, and in expansions of the capillitium. The latter species has been found repeatedly by Mr. Eli Davis near London, Ontario, on what appears to be decayed, black ash wood, although Mr. Davis is not certain about the identification of the wood. In specimens from there, the red oil-knots in the capillitium, and the red granules in the sporangial wall are numerous and prominent. *E. miyazakiensis* has some resemblance to a *Diachea*, but in that genus there are no expansions in the capillitium, and the included material is lime, and confined to the stalk and columella. Because of the scarcity of material, the true nature of the waxy or oily substance has not been confirmed by other investigators.

With two species now known, and having a common character not present otherwise in the Mycetozoa, it is proper they should be placed in a genus on this clear, generic character, rather than in any other genus with which they have only slight and indefinite affinities. The new genus, *Elaeomyxa*, cannot be placed satisfactorily in either of the calcareous families, nor in the Stemonitaceae, but must be regarded as constituting a distinct family, the *Elaeomyxaceae*.—ROBERT HAGELSTEIN.

## FLORIDA RESUPINATE POLYPORES

The following is abstracted from a paper by the author on "Florida Polyporaceae" to appear in bulletin form. It is published here to obtain an earlier and wider circulation.

Hymenophore some shade of white, gray or yellow.

Hymenophore annual ..... 1. *Poria*

Hymenophore perennial; tubes white or pink ..... 2. *Perenniporia*

Hymenophore some shade of purple or red.

Spores hyaline ..... 3. *Physisporinus*

Spores fuscous ..... 4. *Meruliporia*

Hymenophore brown.

Hymenophore annual.

Hymenium irpiciform ..... 5. *Hydnoporia*

Hymenium normally poroid.

Spores hyaline ..... 6. *Fuscoporia*

Spores brown ..... 7. *Fuscoporella*

Hymenophore perennial.

Spores hyaline ..... 8. *Fomitiporia*

Spores brown ..... 9. *Fomitiporella*

Hymenophore black.

Hymenophore annual ..... 10. *Tinctoporia*

Hymenophore perennial ..... 11. *Melanoporia*

### 1. PORIA (Pers.) S. F. Gray

Represented in Florida by 23 described species.

### 2. *Perenniporia* gen. nov.

Hymenophore becoming perennial, rigid; context white or yellow; tubes pinkish, white or yellow, stratoses in older specimens; spores hyaline.

Pileus resupinatus, perennis, induratus; contextu albo vel flavo; tubulis roseis, albis vel flavis, demum stratoses; sporis hyalinis.

*P. unita* (Pers.) Murrill; *P. nigrescens* (Bres.) Murrill.

### 3. PHYSISPORINUS P. Karst.

Represented in Florida by *P. spissus* (Schw.) Murrill and *P. vinctus* (Berk.) Murrill.

4. *Meruliporia* gen. nov.

Hymenophore resupinate, epixylous, effused, annual; pores meruloid, becoming purple to black with age; spores smooth, fuscous.

*Pileus resupinatus, annuus; poris merulioideis, demum purpureis ad nigris; sporis levibus, fuscis.*

***M. incrassata*** (Berk. & Curt.) Murrill.

## 5-11. HYDNOPORIA-MELANOPORIA

These seven genera have already been treated in the author's publications.—W. A. MURRILL.

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BOOK REVIEW

## KARLING'S PLASMIDIOPHORALES

Professor Karling is to be congratulated on producing the first comprehensive treatise on the Plasmodiophorales to appear in America. It is to be hoped that this is but the beginning of a series which will illuminate the complex interrelationships and life cycles of the lower fungi.

The value of this text lies in the complete manner in which the widely scattered literature has been assembled and in the fair and unbiased manner in which the author has used the numerous, though often incomplete, contributions of the past to arrive at his conception of the group as it stands at present. As stated in the preface, the book is intended primarily for graduate and research students of mycology and the lower organisms. Let us hope, however, that teachers of mycology and plant pathology will now revise the first lecture of their courses and present a more comprehensive description of the group than has been customary in the past.

After a brief introduction Karling plunges into a detailed account of the cytology of the various species. This mode of presentation is to be commended because only by cytological studies is it possible to interpret the life cycles and pave the way for the treatment of

<sup>1</sup> Karling, J. S. *Plasmodiophorales* IX + 144 pages, 17 text-figures, 17 plates. Published by the Author, New York City, 1942.

sexuality and alternation of generations, which follows in Chapter III. After this come the detailed classification and descriptions of genera and species, dealt with in a conservative manner on the basis of information now available. This section also includes a full description of all doubtful or excluded species. Chapter V is devoted to questions of phylogeny and relationships with the Myxomycetes, Chytridiales, and Protozoa. It contains much information on other lower organisms with which mycologists ought to be more familiar and also an interesting historical account of the controversy concerning the systematic position of the Plasmodiophorales which has engaged the attention of mycologists and protozoologists for half a century. The final chapter, a very long one, is devoted to club root of crucifers and powdery scab of potatoes. The questions of host specialization and methods of disease control are summarized into tables which should be particularly useful to pathologists.

On the whole I find very little to criticize in this volume. Although plant pathologists would doubtless have welcomed a few photographs of the host plants illustrating disease symptoms, all other phases of the work are adequately illustrated by text figures and numerous line drawings which cover 17 full page plates. A minor error occurs on page 1 where it is stated that all species except members of the genus *Ligniera* cause distortion of the host. *Polymyxa graminis* should be included here with *Ligniera*.

Since the author has endeavoured to stimulate further research on the many unsolved problems to be found in the Plasmodiophorales, the success of his book will best be registered by the rapidity with which a revised edition becomes essential. New species await the resourceful mycologist and even the known forms still present fruitful fields for cytological, morphological and physiological studies.—G. A. LEDINGHAM.

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#### PARASITIC FUNGI OF WISCONSIN

There has recently come to hand a neat little book under the above title. This 157-page volume consists of a record of the parasitic fungi collected and compiled by Dr. J. J. Davis during his life-time. Since his death it has been prepared for the printers by

his colleagues and has been printed through the generosity of his daughter Margaret Davis. It is beautifully bound in board covers and stands out not only as a monument to its author, but a valuable list of the parasitic fungi of Wisconsin with an index both to the fungi and to the hosts on which they occur.

The writer is personally interested in this since it contains a record of *Sclerotinia Geranii* Seaver & Horne, the first record of this species to have been made outside of the type locality in the suburbs of New York City and still, we believe, the first record of the species outside of New York State. No doubt the list contains other equally important records.—F. J. SEAVER.

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#### WHITE'S RUTSTROEMIA<sup>1</sup>

Having been long engaged in the study of the cup-fungi, the writer was naturally interested in reading a recent monograph by Dr. W. Lawrence White on the genus *Rutstroemia*. The title of this note is well worded for it is White's *Rutstroemia* and not Karsten's, since White passed over the first species of the genus, as established by Karsten, which would logically become the type, and in fact has been so designated, and selected, instead, the last of seven species on the list, *Peziza firma*, which had already been used by the writer as the type of the genus *Calycina* S. F. Gray.

In his attempt to justify this, White claims that the genus *Calycina* S. F. Gray, although established on *Peziza firma*, was untenable since the genus was proposed one year before Fries treated the cup-fungi in his *Systema Mycologicum*. Technically this would be correct were it not for the fact that an amendment to the rules is now pending before the International Commission on Nomenclature which would validate S. F. Gray's genera. Until this is acted on officially the throwing out of a genus on such a pretext is, in our opinion, unwarranted.

Another argument used against the writer's attempt to revive one of S. F. Gray's genera is the claim that Gray knew nothing about fungi, and had grouped together in this genus a number of species which are not now regarded as congeneric. This is no

<sup>1</sup> W. Lawrence White. A Monograph of the Genus *Rutstroemia* (Discomycetes). *Lloydia* 4: 153-240. 75 figs. 1941.

more true of S. F. Gray than it is of Karsten or of Fries himself, as has already been pointed out by the writer and others. This is necessarily true of any of the early workers since our concept of the genera is continually changing.

The type of Karsten's' *Rutstroemia* is *Peziza bulgarioides* Rab. (listed by White as one of the excluded species), a synonym of *Peziza strobilina* Fries, and a species which is fairly well known judging from the number of collections in our herbarium. Since this species belongs to an earlier Friesian genus, *Rutstroemia* becomes a straight synonym of that genus. This relegates *Rutstroemia* to synonymy where it should be allowed to remain. White's attempt to retain the name *Rutstroemia* while excluding the type species from the genus is a violation of the rule which reads (Section 2, Art. 18): "*The name of a group must be changed if the type of that name is excluded.*"

From the above it will be seen that while White chides the writer for his so-called attempt to revive a genus founded by S. F. Gray in 1821, on the ground that it is pre-Friesian, he in his attempt to revamp the genus *Rutstroemia*, which had been abandoned by its own author, basing it on a species which even by stretching the rules to their limit could scarcely be regarded as the type, has, to put it plainly, "strained at a gnat and swallowed a camel." A pre-Friesian genus is no more invalid under the rules than a mistreated post-Friesian genus. The fact that it required ten pages of explanations to justify this procedure is evidence that the author realized that his disposition of the matter was highly irregular and would scarcely be accepted by coworkers in the group.

As to the genus itself, the limits seem to be so vague and indefinite that it is difficult even for a student of discomycetes to know whether a species does or does not belong to that genus. To use his own words: "Though the genus as here presented is considered a natural taxonomic unit, there is unfortunately from the practical viewpoint no one character which is infallibly common to all the species."

Although we are unable to accept White's version of the genus, he nevertheless deserves much commendation for the thorough work he has done on the various species treated. This is evident

from the large number of synonyms which he has brought together, by the fine illustrations used, and by the detailed study of the twenty species examined by him, which is equivalent to saying that his eggs are good but the basket in which they are placed is untenable. This can be rectified in a later treatment of the inoperculate cup-fungi.—FRED J. SEAVER, *Member of the International Commission for the Nomenclature of the Fungi.*

# MYCOLOGIA

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## JOSEPH CHARLES ARTHUR (1850–1942)

EDWIN B. MAINS

(WITH PORTRAIT)

Joseph Charles Arthur was born at Lowville, New York, January 11, 1850. At the age of six, he moved with his parents Charles and Ann Arthur to Charles City, Iowa. Here he attended country school and developed an interest in plants which continued throughout his long life. When Iowa State College opened in 1869 he was one of the first students, receiving his botanical training under Professor C. E. Bessey. He graduated with the degree of B.S. in 1872. He returned to Iowa State College in 1876 and received the degree of M.S. the following year. He later studied at Johns Hopkins (1879) and Harvard (1879). In 1886 he was granted the D.Sc. from Cornell University. He received the degree of LL.D. from the University of Iowa in 1916 and D.Sc. from Iowa State College in 1920 and from Purdue University in 1931.

His professional career started at Iowa State College where he was an instructor from 1876 to 1878. Apparently his association with E. W. D. Holway began at this time. This continued for 48 years until Mr. Holway's death in 1923. Mr. Holway's collections of rusts added much toward the completeness of Dr. Arthur's studies, specially for the Tropical American Uredinales. In 1876 Dr. Arthur published his first scientific paper,<sup>1</sup> a catalogue of the flowering plants of Iowa. He also

<sup>1</sup> Contributions to the flora of Iowa; a catalogue of the phaenogamous plants. 43 pp. Charles City, Iowa, 1876.

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exhibited an herbarium of Iowa plants at the Centennial Exhibition in Philadelphia in 1876, receiving a bronze medal.

After serving as an instructor at the University of Wisconsin (1879-1881) and at the University of Minnesota (1882), he was appointed Botanist at the New York Agricultural Experiment Station, Geneva, New York. His was the first appointment to such a position in this country. At Geneva he was mainly concerned with investigations of plant diseases with special emphasis on pear blight. In the mycological field he published a paper<sup>2</sup> concerning a species of *Entomophthora*.

In 1887, he accepted the position of Professor of Botany at Purdue University and the following year became Professor of Vegetable Physiology and Pathology and Botanist in the Purdue University Agricultural Experiment Station. As such he continued until his retirement in 1915 as Professor Emeritus of Botany. In 1901 he married Emily Stiles Potter of Lafayette, Indiana, who died in 1935.

Throughout his life Dr. Arthur was an indefatigable investigator and writer in the fields of physiology, pathology and mycology. In addition to publishing a number of papers concerning the physiology of plants he exhibited apparatus of original design at the Columbian Exposition in Chicago in 1893. He was among the pioneers in plant pathology, his most important contribution being the use of formaldehyde as a fungicide, specially for the scab of potatoes.

In the mycological field he was early recognized as an authority for the Uredinales. His first paper<sup>3</sup> concerning the group was published in 1883. For many years after his retirement in 1915 he continued his rust studies. His last publication was the "Manual of the Rusts of the United States and Canada" (1934). Thus for over half a century he added to the knowledge of the Uredinales, contributing more than 100 articles to botanical journals and publishing three major publications.<sup>4</sup>

<sup>2</sup> A new larval *Entomophthora*. Bot. Gaz. 11: 14-16. 1886.

<sup>3</sup> The interpretation of Schweinitzian and other early descriptions. Am. Nat. p. 77-78. 1883.

<sup>4</sup> Uredinales. N. Am. Flora 7: 83-969. 1907-1931. Plant rusts, in collaboration with F. D. Kern, C. R. Orton, F. D. Fromme, H. S. Jackson, E. B. Mains, G. R. Bisby. 446 pp. 1929. Manual of the rusts in United States and Canada. Illustrations by George B. Cummins. 438 pp. 1934.

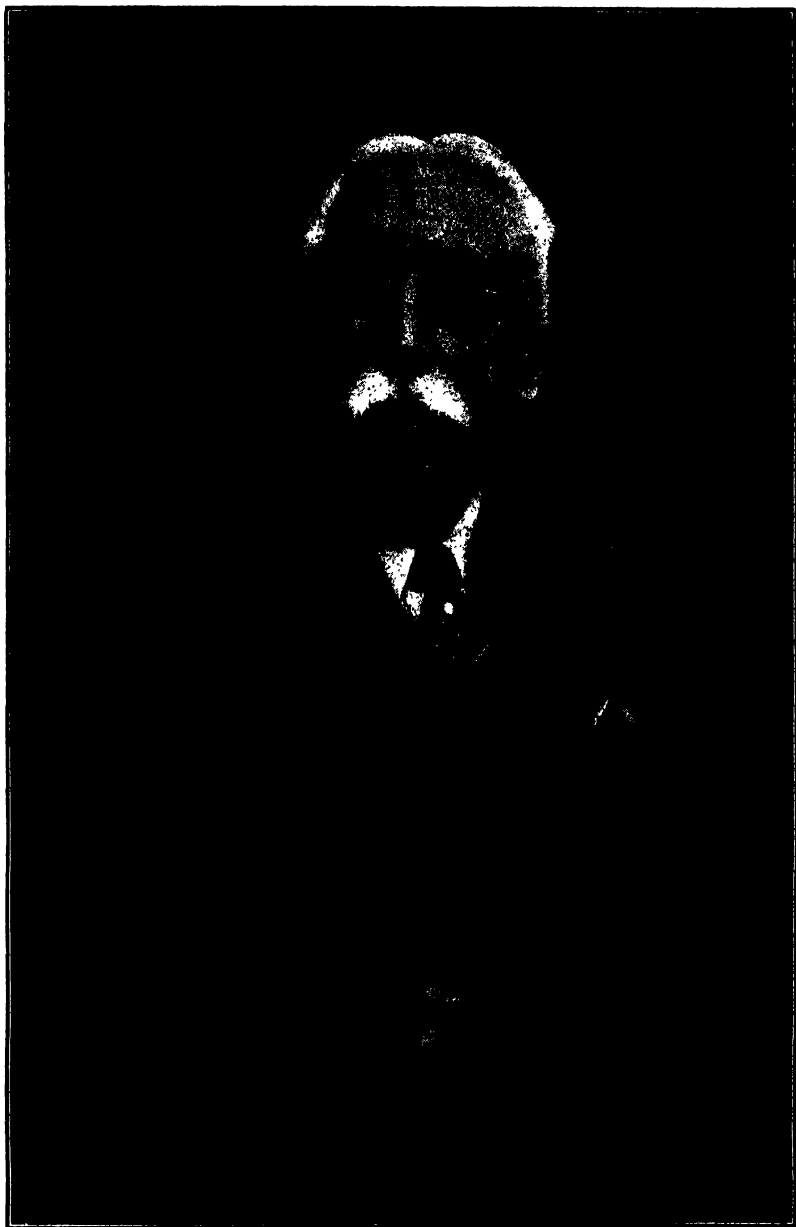


FIG. 1. Joseph Charles Arthur. (Photograph by George F. Weber, Nov. 24, 1937.)

With the establishment of a plan for the publication of a Flora of North America by the New York Botanical Garden, Dr. Arthur assumed the responsibility of providing a complete taxonomic treatment of the Uredinales. The first number was published in 1907. After his retirement, support for the study was continued by the Purdue Agricultural Experiment Station and the last number was completed in 1931.

He was early faced with the multiplicity of names and difficulties in establishing species concepts. Little was known concerning the heteroecism of North American species. This necessitated field studies to establish the association of alternate hosts, involving extensive trips throughout the United States. He was also aided by many correspondents who furnished additional information and collections. For nineteen years, May and June were busy months in the laboratory at Purdue. With the help of a special assistant, overwintered collections of teliospores were tested for germination and cultures were attempted on selected hosts. The routine was relieved by the excitement attending the first demonstration of a new connection. The results of these studies were published yearly and they were summarized by Dr. Arthur in 1921.<sup>5</sup>

In these studies of host relationships he was soon confronted with the problem of host specialization in relation to the species concept. He finally concluded that "morphological characters must be the final test for the species." This emphasis on morphology resulted in the employment of characters which had received little or no use previously, specially the number and arrangement of germ pores in the spores.

The importance given to the pycnium (spermagonium) and the stages with which it was associated resulted in the employment of life cycles in the delimitation of genera with a considerable multiplication of genera in the treatment in the North American Flora. This did not find general acceptance and was finally abandoned in the Manual of Rusts for North America. However, there resulted a better understanding of the life cycles of species. Another result was the proposal of a more usable terminology of the various spore stages which has found general acceptance in North America.

<sup>5</sup> *Mycologia* 13: 12-23; 230-262. 1921.

An herbarium of 60,000 specimens of rusts was developed. Comparison of collections was facilitated through the use of a uniform system for drawings and notes. This herbarium in the Botany Department of the Agricultural Experiment Station of Purdue University has been designated the Arthur Herbarium.

Dr. Arthur was a member of Sigma Xi, Phi Kappa Phi, Societe Mycologique de France (1884-1889), Association Internationale des Botanistes (1901-1915), Deutsche Botanische Gesellschaft, Society for Promotion of Agricultural Science (1886-1920), Botanical Society of America, American Mycological Society (1903-1906), Torrey Botanical Club, Washington Academy of Science (1905-1912), Plant World Association (1907-1919), American Phytopathological Society, American Association of University Professors, American Philosophical Society, American Society of Naturalists, Mycological Society of America and corresponding member of the Academy of Natural Science of Philadelphia. He was a fellow of the American Association for the Advancement of Science, the Indiana Academy of Science and the American Academy of Arts and Science and honorary fellow of the Iowa Academy of Science. He was elected vice-president (1897), and president (1901 and 1919) of the Botanical Society of America; president of the American Phytopathological Society (1933); president of the Indiana Academy of Science (1892); assistant general secretary of the American Association for the Advancement of Science (1887) of which he was also secretary of section F in 1886 and vice-president of section G in 1895. He served as associate editor (1883-1885; 1900-1904) and editor (1886-1900) of the Botanical Gazette and associate editor of Mycologia (1909-1932). He was one of the organizers and secretary of the Madison Botanical Congress in 1893 and a delegate to the International Botanical Congress at Vienna in 1905 and at Brussels in 1910.

Dr. Arthur died at Brook, Indiana, April 30, 1942, and was buried at Lafayette, Indiana. It is given to few men to have such a long active life. His scientific achievements will serve as an everlasting monument.

UNIVERSITY OF MICHIGAN,  
ANN ARBOR, MICHIGAN

# DISTRIBUTION PATTERNS IN MELAMPSORELLA IN THE NATIONAL FORESTS AND PARKS OF THE WESTERN STATES<sup>1</sup>

S. M. PADY

(WITH 3 FIGURES)

*Melampsorella* is the cause of a witches' broom rust disease on various species of *Picea* and *Abies*. Although the disease has long been known due to its conspicuous appearance and wide distribution, considerable confusion exists at present as to the number of species. Earlier investigators (3) described two species under the form genus *Peridermium*, one species on *Abies*, the other on *Picea*. Subsequent workers, among them Rhoads et al (7), subscribed to this concept. Arthur (2) has recently considered the genus to be monotypic basing his conception on the character of the pycnia which he considers to be subcuticular in both forms. In 1939 the writer made a comparative study (5) of infections on *Abies* and *Picea*, particularly with reference to the pycnia, and discovered that they are distinctly different, being subcuticular and flattened on *Abies* as earlier reported (4), but subepidermal, actually *substomatal* and spherical, on *Picea*. These differences, plus others among which may be mentioned the size, color, markings, and date of maturity of the aeciospores, and the size and manner of growth of the witches' brooms, have convinced the writer that there are two species of this rust. In a later paper (6) additional information was obtained on the nature of the substomatal pycnia from a study of fresh material and from specimens in the Arthur Herbarium, and further evidence was presented in support of this conclusion. This paper presents the results of studies made during the summer of 1941 on the distribution patterns of these two species, as well as evidence based on field observations and collections.

<sup>1</sup> With the support of a grant from the Penrose Fund of the American Philosophical Society.

In the Gothic area of Colorado previously studied (5, 6) infections were very numerous on *Picea* yet scarce on *Abies*, notwithstanding the fact that the latter occurred abundantly throughout the region. It was suspected that if such differences occurred in other areas it might constitute further evidence for the delimitation of the two species. Localities were selected for detailed study on the basis of the presence of the hosts and the rust. Data on the distribution of the disease were obtained from specimens in the Arthur Herbarium at Purdue University and from a list of the specimens in the Forest Pathology Herbarium, Bureau of Plant Industry, Washington, D. C.,<sup>2</sup> and from correspondence with officials of the National Parks and National Forests.<sup>3</sup> Data on the distribution of the *Picea* and *Abies* species were obtained from various sources, mainly from Bailey's "The Cultivated Conifers" and Munn's maps of the distribution of forest trees (U. S. D. A., M.P. 287). Numerous collections (Table I) and many detailed observations were made in these areas. It was found that the two species differed in their distribution and two distinct distribution patterns were obtained (Table II and FIG. 1). A brief description of the situation in each area is given below.

#### UINTAH NATIONAL FOREST, UTAH

In the Uintah N.F. north of Hanna, along Wolf Creek on Highway 53, *Melampsorella* occurs abundantly on *Abies lasiocarpa*, some areas being very heavily infected. In one area, for example, over 250 witches' brooms were counted on *Abies* and only 6 were found on *Picea*, 3 of these being dead. Practically every tree had one or more brooms upon it and one large tree had over 30. One tree 7' tall, base 4" diameter, had 4 witches' brooms, 3 being dead, one terminal broom surrounding the trunk, and checking normal growth. The brooms were of all sizes, the larger ones being very conspicuous. New growth was just beginning and the pale yellowish green young leaves gave the brooms a yellowish cast in striking contrast with the normal dark

<sup>2</sup> The assistance of Dr. R. Kent Beattie in preparing the list and for his many helpful suggestions is gratefully acknowledged.

<sup>3</sup> The success of the trip was due in large measure to the excellent cooperation of these officials. Their assistance was greatly appreciated.

TABLE I

RECORD OF COLLECTIONS OF MELAMPSORELLA IN THE NATIONAL FORESTS  
AND PARKS IN 1941

| Date     | Host                                       | Collections | Locality                     |
|----------|--|-------------|------------------------------|
| June 9th | <i>Abies lasiocarpa</i>                    | 4           | Uintah N.F., Utah            |
| " 13th   | <i>Picea pungens</i>                       | 2           | Wasatch N.F., Utah           |
| " 14th   | <i>Abies lasiocarpa</i>                    | 1           | " " "                        |
| " "      | <i>Picea Engelmanni</i>                    | 1           | " " "                        |
| " 17th   | <i>Picea pungens</i>                       | 5           | Powell N.F., Utah            |
| " 19th   | " "  | 3           | Grand Canyon N.P., Ariz.     |
| " "      | " "  | 1           | Kaibab N.F., Ariz.           |
| July 3rd | <i>Abies magnifica</i>                     | 2           | Yosemite N.P., Calif.        |
| " 12th   | <i>A. magnifica</i> var. <i>shastensis</i> | 1           | Crater Lake N.P., Ore.       |
| " 15th   | <i>Abies amabilis</i>                      | 1           | Mt. Hood N.F., Ore.          |
| " 17th   | <i>Picea Engelmanni</i>                    | 1           | Mt. Rainier N.P., Wash.      |
| " 23rd   | <i>Abies lasiocarpa</i>                    | 2           | Glacier N.P., Mont.          |
| " "      | <i>Picea glauca</i>                        | 1           | Blackfeet Indian Res., Mont. |
| " 25th   | <i>Picea Engelmanni</i>                    | 1           | Yellowstone N.P., Wyo.       |
| " "      | <i>Abies lasiocarpa</i>                    | 3           | " " "                        |
| " "      | " "  | 5           | " " "                        |
| " "      | <i>Picea pungens</i>                       | 2           | " " "                        |
| " 26th   | <i>Picea Engelmanni</i>                    | 3           | " " "                        |
| " 27th   | <i>Abies lasiocarpa</i>                    | 1           | " " "                        |
| " "      | <i>Picea Engelmanni</i>                    | 4           | " " "                        |
| " "      | " "  | 1           | " " "                        |
| " "      | <i>Picea pungens</i>                       | 2           | " " "                        |
| " 28th   | <i>Abies lasiocarpa</i>                    | 1           | Teton N.F., Wyo.             |
| " "      | " "  | 2           | Grand Teton N.P., "          |
| " 29th   | <i>Picea Engelmanni</i>                    | 1           | Wyoming N.F., Wyo.           |
| " "      | <i>Abies lasiocarpa</i>                    | 1           | " " "                        |
| " 30th   | <i>Picea Engelmanni</i>                    | 4           | Medicine Bow N.F., Wyo.      |
| " "      | <i>Picea pungens</i>                       | 2           | " " "                        |
| " "      | <i>Abies lasiocarpa</i>                    | 3           | " " "                        |
| Aug. 1st | <i>Picea Engelmanni</i>                    | 3           | " " "                        |
| " "      | <i>Abies lasiocarpa</i>                    | 6           | " " "                        |
| " 3rd    | <i>P. glauca</i> var. <i>albertiana</i>    | 4           | Black Hills N.F., S. D.      |
| " "      | <i>P. glauca</i> var. <i>albertiana</i>    | 1           | Harney N.F., S. D.           |
| Total    |  | 75          |                              |

green foliage. The infected buds were also greatly advanced over normal buds which did not as yet show any growth. At higher altitudes around 9000' the brooms were still dormant, but at lower altitudes the infected branches were  $\frac{1}{2}$ " long.

Pycnia were present on the closely packed leaves but mature pycnia were found only on the exposed portion of the leaf. Except for the stomatal areas which do not bear them, the pycnia are scattered over the leaf being most numerous at the tip. A peculiar feature of the pycnial stage on *Abies* was a very pronounced disagreeable odor; the pycnia on *Picea* did not give off any odor that was particularly apparent. While the possible function of the odor remains a matter of conjecture it does emphasize a further point of difference in the two species.

TABLE II  
COLLECTIONS AND DETAILED OBSERVATIONS OF MELAMPSORELLA IN THE  
NATIONAL FORESTS AND PARKS IN 1941

| Locality                                   | ON PICEA |          |                  | ON ABIES |          |                     |
|--|----------|----------|------------------|----------|----------|---------------------|
|  | Col.     | Det. Ob. | Comments         | Col.     | Det. Ob. | Comments            |
| <i>Utah N.F., Utah</i>                     |          |          |                  |          |          |                     |
| Wolf Creek, N. of Hanna.....               | —        | 2        | Rare             | 4        | 10       | Moderately heavy    |
| Summit H'way 53.....                       | —        | —        | Few, scattered   | —        | —        | Abundant            |
| <i>Wasatch N.F., Utah</i>                  |          |          |                  |          |          |                     |
| Trail to Alexander Lake.....               | 2        | 2        | Scattered        | —        | 2        | Light, scattered    |
| Along Provo River.....                     | 1        | 2        | Abundant         | 1        | 1        | Few                 |
| <i>Powell N.F., Utah</i>                   |          |          |                  |          |          |                     |
| E. of Widtaco.....                         | 5        | 20       | Very heavy       |          |          | Host absent         |
| <i>Grand Canyon N.P., Ariz.</i>            |          |          |                  |          |          |                     |
| Along N. Rim.....                          | 3        | 33       | Heavy            | —        | —        |                     |
| <i>Kaibab N.F., Ariz.</i>                  |          |          |                  |          |          |                     |
| Southern Border.....                       | 1        | 2        | Scattered        | —        | —        |                     |
| <i>Sequoia N.F., Calif.</i>                |          |          |                  |          |          |                     |
| Halstead Creek.....                        |          |          | Host absent      | —        | 5        | Light               |
| <i>Yosemite N.P., Calif.</i>               |          |          |                  |          |          |                     |
| Washburn Point and vicinity.....           |          |          | Host absent      | 2        | 13       | Heavy in this area  |
| <i>Crater Lake N.P., Ore.</i>              |          |          |                  |          |          |                     |
| 2 mi. E. of Headquarters.....              |          |          | Host absent      | 1        | 1        | Rare, one infection |
| <i>Mt. Hood N.F., Ore.</i>                 |          |          |                  |          |          |                     |
| Below Timberline Lodge.....                |          |          | Host absent      | 1        | 6        | Light               |
| <i>Mt. Rainier N.P., Wash.</i>             |          |          |                  |          |          |                     |
| Trail to Emmons Glacier.....               | 1        | 3        | Light            | —        | —        |                     |
| <i>Glacier N.P., Mont.</i>                 |          |          |                  |          |          |                     |
| H'way E. and W. of Logan Pass.....         | —        | 10       | Heavy            | 2        | 3        | Moderate            |
| <i>Plackfeet Indian Reservation, Mont.</i> |          |          |                  |          |          |                     |
| 10 mi. S. of St. Marys.....                | 1        | 1        |                  | —        | —        |                     |
| <i>Yellowstone N.P., Wyo.</i>              |          |          |                  |          |          |                     |
| Artists' Point and vicinity.....           | 1        | 1        | Uncommon         | 3        | 6        | Heavy               |
| Mt. Washburn and vicinity.....             | —        | 1        | Fairly abundant  | 5        | 4        | Moderately heavy    |
| Mammoth Hot Springs and vicinity.....      | 2        | 2        | Abundant         | —        | —        |                     |
| Madison Jet. and vicinity.....             | 3        | 3        | Very heavy       | —        | —        |                     |
| Along Firehole River.....                  | 4        | 2        | Heavy            | —        | —        |                     |
| Vicinity of Old Faithful.....              | —        | —        |                  | 1        | 2        | Light               |
| Yellowstone Lake, W. shore.....            | 3        | 6        | Epidemic         | —        | —        |                     |
| <i>Teton N.F., Wyo.</i>                    |          |          |                  |          |          |                     |
| Road S. Yellowstone Park.....              | —        | —        |                  | 1        | 1        | Numerous            |
| <i>Grand Teton N.P., Wyo.</i>              |          |          |                  |          |          |                     |
| Jenny Lake.....                            | —        | —        |                  | 2        | 3        | Light, scattered    |
| <i>Wyoming N.F., Wyo.</i>                  |          |          |                  |          |          |                     |
| Hqback Canyon.....                         | 1        | 1        | Moderately heavy | 1        | 1        | Light               |
| <i>Medicine Bow N.F., Wyo.</i>             |          |          |                  |          |          |                     |
| Univ. of Wyo. Camp and vicinity.....       | 3        | 2        | Heavy            | 1        | 2        | Light               |
| Libby Flats.....                           | 1        | 3        | Light            | 1        | 1        | Heavy               |
| Upper Nash Fork Camp Ground.....           | 2        | 2        | Abundant         | 1        | 1        | Light               |
| Albany and Keystone and vicinity.....      | 1        | 2        | Heavy            | —        | 1        | Scattered           |
| Mullen Creek and vicinity.....             | —        | 2        | Fairly abundant  | —        | —        |                     |
| N. Mullen Creek.....                       | 2        | 3        | Fairly abundant  | —        | —        |                     |
| Vicinity Encampment.....                   | —        | 1        | Light            | 1        | 2        | Moderate            |
| Vicinity Battle Lake.....                  | —        | —        |                  | 4        | 7        | Epidemic            |
| Sagestone Ranger Station.....              | —        | —        |                  | 1        | 1        | Light               |
| <i>Black Hills N.F., S. D.</i>             |          |          |                  |          |          |                     |
| Black Fox Camp Ground and vicinity....     | 3        | 5        | Heavy            |          |          | Host absent         |
| Deerfield Camp Ground and vicinity....     | 1        | 1        | Moderate         |          |          | Host absent         |
| <i>Harney N.F., S. D.</i>                  |          |          |                  |          |          |                     |
| 4 mi. N. of Custer.....                    | 1        | 4        | Heavy            |          |          | Host absent         |

The witches' brooms of the species on *Abies* are typically compact with a dense growth of many small branches, somewhat spherical, often rather symmetrical, and rarely exceeding a diameter of 2'-3'. The infected leaves are deciduous but are not usually cast until the spring; during the winter they become dark



in color and somewhat shrivelled, which with the bare older branches, give the entire broom a dark somewhat lifeless appearance during the dormant season. The gall is prominent especially when the broom is located on a young branch.

The witches' brooms of the species on *Picea* are extremely irregular, the terminal bud growing much more rapidly than the lateral buds, which results in a larger more diffuse type of broom. Sometimes long pendant branches are found on these brooms. The infected branches are pale brown in color and thus the dormant brooms are usually paler than those on *Abies*.

The infected branches of both species sometimes display marked changes in geotropism. The normal branches are transversely geotropic while the infected branches tend to be negatively geotropic. In some cases the entire broom has been found growing at right angles to the lateral branch on which it is located.

In the vicinity of Wolf Creek Summit and along Highway 53 further west, many infections were observed on *Abies*, few on *Picea*; those on the former were all dense, compact, many being dead. In this entire region both hosts were abundant but the species of *Melampsorella* on *Abies* is clearly dominant, a situation found to exist throughout this region.

#### WASATCH NATIONAL FOREST, UTAH

Along Provo River, east of Kamas, and in the Provo River Canyon, witches' brooms were not especially abundant. Infections on both hosts were scattered and occurred as single usually isolated infections. In one area the *Picea* form was fairly abundant. In this region infections were not heavy enough to justify any conclusions, although it would seem to indicate that the form on *Picea* is most numerous and tends to be dominant. It is interesting to note the different situation here, although only a few miles from the Uintah area.

#### POWELL NATIONAL FOREST, UTAH

Driving east from Widtsoe, Utah, along the road to Escalante one encounters a densely forested area in which *Melampsorella*

is very abundant on *Picea pungens*, the only host that grows here. This area begins  $4\frac{1}{2}$  miles from Widstoe and continues for almost two miles. Infections were heavy, the brooms generally large and conspicuous, often reaching a diameter of 4'-6'. As is typical of the species on *Picea* many of the brooms were very irregular; one broom for example completely surrounded the main trunk of a large tree, extending from the base upward to a distance of 6'. The size of the witches' brooms was extremely variable, infections being found in all stages of growth. On one small tree 19' high the broom was terminal, forming a dense irregular mass at the top of the tree; the broom was dead and the tree was dying. In one other similar case the terminal bud of the trunk had become infected checking further growth, but a lateral bud had grown up around the broom to continue the normal growth of the tree. There was evidence in this area of considerable damage to the trees; one large tree with a base 2' in diameter had a mass of infected branches 20' from the top, the mass was 10'  $\times$  6' in diameter and was dead, as was the trunk from that point upward, suggesting that the infection had killed the tree.

Witches' brooms were found on all parts of the tree, the most conspicuous being those which occurred high up either on the main trunk or on lateral branches where the infected mass stood out clearly against the sky. Of the brooms studied, 2 were terminal on the main trunk, 9 were found at various points along the trunk, 1 was terminal at the end of a lateral branch, 2 were located on a lateral branch, and 1 was found at the junction of a lateral branch and the main trunk. The large number of main trunk infections recorded is probably due to the fact these were so conspicuous that more of them were noted.

The infected buds were emerging much in advance of the normal buds which showed little or no growth, while the infected branches were  $\frac{1}{4}$ "- $\frac{1}{2}$ " in length. An examination of the pycnia shows they differ greatly from those previously noted on *Abies*; in appearance being darker and smaller, in distribution being confined to the stomatal rows on the four sides of the leaf, and also in the absence of any apparent odor.

## GRAND CANYON NATIONAL PARK, ARIZONA

In the heavily forested region of the North Rim of the Grand Canyon National Park, *Melampsorella* was found abundantly on *Picea pungens*. *Abies concolor* is present there also but no infections were found upon it. One of the outstanding characteristics of infections found in this area was the large size attained by some of the witches' brooms, a large number of them reaching a diameter of 8'; one of the largest measured 10'  $\times$  6'  $\times$  5'. The irregularity of many of these larger brooms plus the fact that some of them are partially dead, suggests that coalescence of two or more adjacent brooms may have taken place. The rapidly growing diffuse type of broom found on *Picea* would enable this to take place rather readily.

Several cases were observed where large trees had been snapped off at a point where the main trunk was infected. One such tree, broken 30' from the ground, bore a large irregular mass of infected branches at the point of breakage, and more than 20 witches' brooms of all sizes were scattered over the remainder of the tree, many of them dead. The broken top of the tree also had several brooms on it. The suggestion was very strong that the trunk infections had weakened the tree to such an extent that it was susceptible to breakage, caused possibly by high winds.

There were numerous trees here which were dead or partially dead, the result presumably of heavy infection since there were many dead or partially dead witches' brooms on the same tree. Young trees as a general rule were living even though heavily infected. One tree, 5' high with a basal diameter of 3", had a broom 12"  $\times$  16" surrounding the trunk at the base. Since both the host and parasite were approximately the same age it was evident that infection had taken place during the seedling stage. Each year as the broom becomes larger and larger the demands made upon the host are correspondingly greater, the result being the premature death of the tree.

This area demonstrates very clearly the different distribution patterns of the two species of *Melampsorella* since both *Picea* and *Abies* are present here in abundance, although infections are found only on the former. Conditions in this area were not only

favorable for infection since brooms of all sizes were found on both young and old trees, but were also favorable for the growth of *Picea pungens* and many of the trees grew to a great size. The largest and most conspicuous witches' brooms encountered during the summer's collecting were found in this area.

#### KAIBAB NATIONAL FOREST, ARIZONA

In this National Forest infections were found only at the southern extremity in a small area immediately bordering the Grand Canyon National Park. The total number of witches' brooms found in this region was 10, all being on *Picea pungens*; none were found on *Abies*, although *A. concolor* was present.

#### SEQUOIA NATIONAL PARK, CALIFORNIA

Along the western coast *Melampsorella* does not occur very heavily in any one locality. Most of the infections found were scattered and often difficult to find. In the Sequoia National Park, for example, a search was made for this rust and it was located in only one locality, about 10 miles from the Giant Forest in the region of Halstead Creek, where a total of 5 witches' brooms were observed at scattered points, all on *Abies magnifica*. Although the trees were very tall and the brooms inaccessible their bright yellow color made them conspicuous and the dense compact type of growth was readily observed. The mistletoe brooms on the same host frequently had a superficial resemblance to *Melampsorella*, due to the fact that the mistletoe is yellow in color and also stimulates the production of adventitious branches. There are no species of *Picea* growing in this region.

#### YOSEMITE NATIONAL PARK, CALIFORNIA

The disease was found abundantly in only one area in the Park, on *Abies magnifica* along the road to Glacier Point in the vicinity of Washburn Point. As in Sequoia National Park, mistletoe was very abundant and conspicuous and care had to be taken in determining the nature of some of the larger brooms which were not accessible for close observation. *Melampsorella*, however, may be readily distinguished from the mistletoe by the fact that the infected leaves are etiolated and the branches bear

only the season's leaves, while in the mistletoe broom the leaves are normal and are retained for several years. The yellow color of this broom is due to the yellow color of the mistletoe itself. Most of the infected branches of *Melampsorella* had attained a growth of  $1\frac{1}{2}$ "-2" and were bright yellow in color, and hence

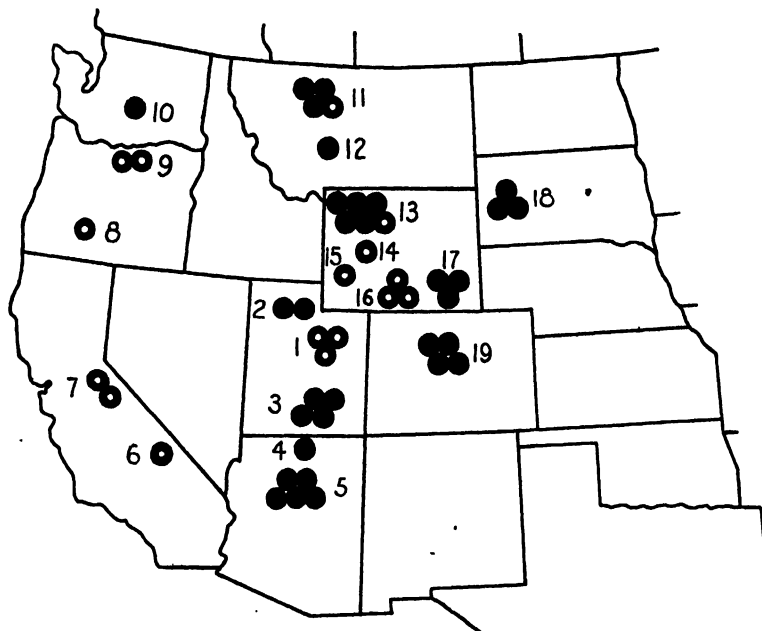


FIG. 1. The distribution patterns of the species of *Melampsorella*. The solid circles represent areas where the species on *Picea* is dominant; hollow circles represent areas where the species on *Abies* appears to be dominant. 1, Uintah National Forest, Utah; 2, Wasatch N. F., Utah; 3, Powell N. F., Utah; 4, Kaibab N. F., Ariz.; 5, Grand Canyon National Park, Ariz.; 6, Sequoia N. P., Calif.; 7, Yosemite N. P., Calif.; 8, Crater Lake N. P., Ore.; 9, Mt. Hood N. F., Ore.; 10, Mt. Rainier N. P., Wash.; 11, Glacier N. P., Mont.; 12, Black-foot Indian Reservation, Mont.; 13, Yellowstone N. P., Wyo.; 14, Teton N. F., Wyo.; 15, Grand Teton N. P., Wyo.; 16, Medicine Bow N. F., Wyo. (Haydn Division); 17, Medicine Bow N. F., Wyo.; 18, Black Hills N. F. and Harney N. F., S. D.; 19, Gunnison N. F., Colo. (See text for details.)

the brooms were conspicuous objects. All of the brooms were of the compact regular type, most of them being 2'-3' in diameter but occasionally slightly larger. Galls were especially prominent on the infected branches. The pycnia were clearly evident being very numerous at the tip of the leaf where they

appeared to be mature, becoming progressively fewer and less mature toward the base. They were also less abundant on the inner surface of the leaf, that is, the side adjacent to the branch.

#### CRATER LAKE NATIONAL PARK, OREGON

Infections of *Melampsorella* are not common in this park, although two collections by Weir have been made, according to specimens in the Forest Pathology Herbarium at Washington. A single witches' broom was located on *Abies magnifica* var. *shastensis* about 2 miles from the Park Headquarters on the road to the south entrance. It was growing on a lateral branch 2' from the trunk and 15' from the ground, reaching a size 5'  $\times$  2'  $\times$  3' but being very irregular. Most of the infected branches were 1½"-2" in length and the individual leaves were ¼"-½" long, pale yellow in color, and bearing bright yellow conspicuous pycnia, which were scattered over the leaf, except in the stomatal areas. This witches' broom was very conspicuous with its pale yellow leaves and light colored branches against the dark green normal foliage. Conditions here are apparently unfavorable for the development and spread of this rust.

#### MOUNT HOOD NATIONAL FOREST, OREGON

The only observations and collections made in this area were taken on the road to Timberline Lodge at an elevation of about 5,000'. Most of the brooms were inaccessible but one collection was made. This specimen was from a small irregular witches' broom on a lateral branch bearing a prominent gall with several straggling hanging infected branches 1'-2' long. The host is *Abies amabilis* and represents what is believed to be a new locality for the disease on this host, it having been reported previously only in Washington. The disease is apparently not widely spread in this forest.

#### MOUNT RAINIER NATIONAL PARK, WASHINGTON

The situation here is similar in one respect to those mentioned in the last four areas, namely that there appear to be few infections. In the one area in Mt. Rainier National Park where the disease was collected the species on *Picea* was present. In this

respect it differed greatly from other areas along the coast where the rust occurred only on *Abies*. A total of 3 witches' brooms was observed, all on *P. Engelmanni* on the trail to Emmons Glacier, about 4/5ths of a mile from White River Camp Ground. *Abies* trees were also present in the immediate vicinity but were free from infection. By this time (see Table I) the aecia were beginning to mature and the broom was beginning to assume a yellowish-red tinge. The witches' brooms were typical of those found on *Picea*, being large and very irregular.

#### GLACIER NATIONAL PARK, MONTANA

In this area infections were found on both *Picea Engelmanni* and *Abies lasiocarpa*, the former being heavily attacked while on the latter brooms were found only occasionally. Along the Going-to-the-Sun Highway witches' brooms are especially conspicuous, some of them becoming very large and often occurring in considerable numbers. An interesting collection was made near Logan Pass on the stunted timberline growth of *A. lasiocarpa*. Under such adverse conditions the trees make but a small amount of annual growth, which would mean that it would be especially difficult for a rust to establish itself here. The trees were all about 9' tall and the witches' broom was 8"  $\times$  12" with very dense, compact growth. As might be expected the short growing season also affects the size of the brooms and the annual growth increment is very slight. The infected season's branches ranged from  $\frac{1}{4}$ "-1" in length, the majority being between  $\frac{1}{4}$ " and  $\frac{1}{2}$ ". That this represents the average annual growth is shown by studying the older branches of the broom. One branch  $4\frac{1}{2}$ " long was 9 years old. The growth each year, beginning with the current season, measured  $\frac{1}{2}$ ",  $\frac{1}{2}$ ",  $\frac{1}{2}$ ",  $\frac{5}{8}$ ",  $\frac{5}{8}$ ",  $\frac{1}{2}$ ",  $\frac{1}{2}$ ",  $\frac{1}{4}$ ",  $\frac{1}{4}$ " respectively.

About 10 miles south of Glacier National Park in the Black-foot Indian Reservation one collection was made on *Picea glauca*, which appears to be a new record for the rust on this host.

#### YELLOWSTONE NATIONAL PARK, WYOMING

*Melampsorella* is widely distributed on both *Picea Engelmanni* and *Abies lasiocarpa* throughout this entire area, the infections

varying from light to extremely heavy, in one case reaching epidemic proportions (Table II). In some areas the species on *Abies* was dominant, in other areas the situation is completely reversed. In no area were the two species ever found in a condition approaching equality. The results of the work in this area are summarized in figure 2. It will be noticed that the species on *A. lasiocarpa* was dominant in the region north of Canyon Junction around Mt. Washburn, where infections were heavy, and in the vicinity of Old Faithful, where the brooms were scattered. On the other hand the species on *P. Engelmanni* occurred rather widely throughout the Park (FIG. 2; Tables I and II) being in abundance in the region of Madison Junction and in epidemic proportions in one locality midway between Lake and Thumb, on Yellowstone Lake. In this latter area witches' brooms were found in practically every tree in the area; 95 brooms were found in 19 trees, 34 on one tree, 26 on another. Because the disease is so abundant and widely spread it provides an excellent opportunity for working out the distribution of two species and reference to figure 2 will indicate the two distinct distribution patterns.

Many very young infections were found, several consisting of single unbranched stems 1"-2" long growing on branches which were presumably free from the rust since they bore normal leaves. These cases were believed to represent very early infection, possibly occurring in the spring, although it is conceivable that infection may have taken place at some time during the preceding year, making these infections two years old. Irrespective of the time of infection, concerning which little or nothing is known, the invaded area was confined to the season's growth and the leaves were yellowish green in color and the stems slightly hypertrophied and pale brown in color. Most of these cases occurred on *P. Engelmanni*.

Two and three year old infections are characterized by the presence of supernumerary branches; one broom 3 years old had 2 main branches bearing a total of 22 infected branches, 10 being on one branch and 12 on the other. A young tree of *P. Engelmanni*, 12' in height, had 9 small witches' brooms, the largest being 6" in diameter, the remainder being much smaller and the



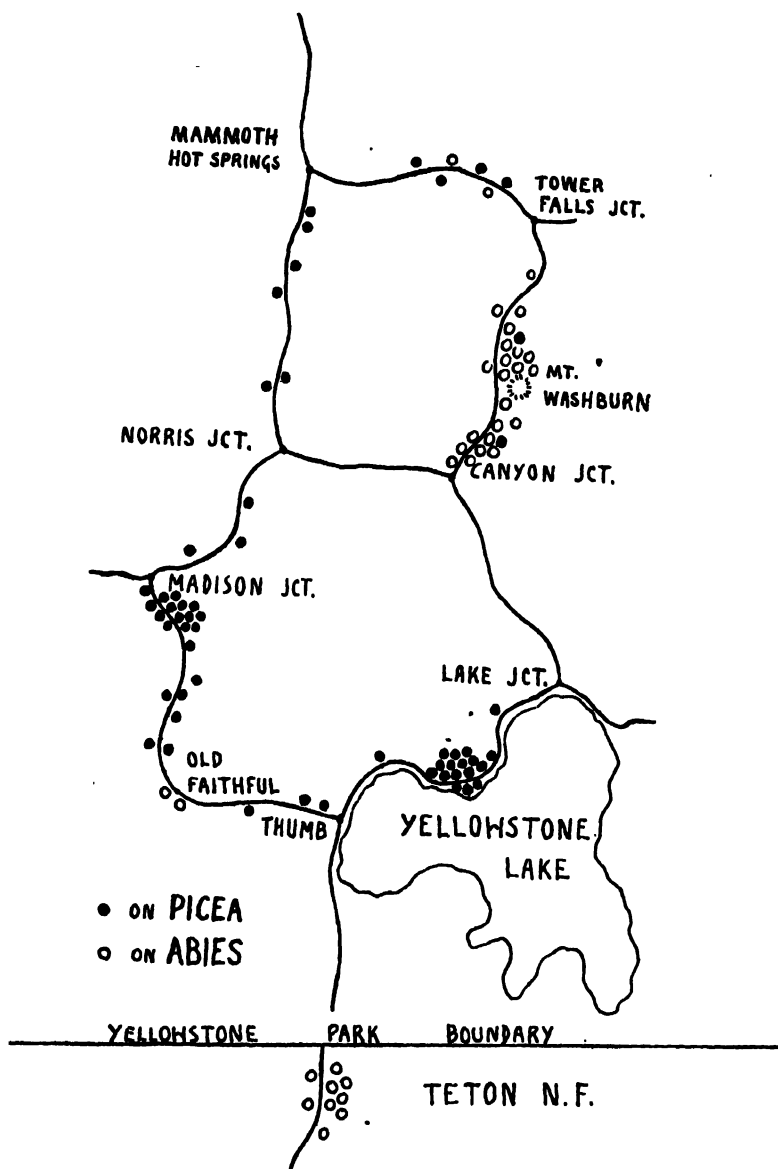


FIG. 2. Distribution patterns of infections in Yellowstone National Park, Wyoming. The disease is widely distributed throughout the area and two distinct patterns are evident. Solid circles represent infections on *Picea*, hollow circles represent infections on *Abies*. (See text for details.)

youngest being a single infected branch. One four year old infection was found on *A. lasiocarpa* with 10 infected branches, each being 1"-2½" in length, hypertrophied, pale in color, and bearing only the season's needles.

The rust was found on *Cerastium*, the alternate host, in great abundance in the Mt. Washburn area just below timberline within a few yards of a large specimen of *A. lasiocarpa* bearing several brooms. It would seem that conditions in this area are ideal from the standpoint of the spread of the disease. Both hosts are present in considerable numbers, there is an abundance of inoculum and conditions are favorable for the growth of the hosts as well as for infection. The problem of eradicating the disease from this area would be extremely difficult since the rust is systemic and perennial on *Cerastium* as well as on its coniferous hosts.

#### GRAND TETON NATIONAL PARK AND VICINITY

In the Teton National Forest extending southward from the southern boundary of the National Park numerous infections were found on *A. lasiocarpa*, particularly along the highway. In the Grand Teton National Park a few scattered infections were found on the same host along the east shore of Jenny Lake. One of these was a conspicuous broom being terminal on a lateral branch, about 4' from the ground and 3' from the trunk, very dense, compact, measuring 3' X 2' X 2', yellow in color and sporulating. The contrast between the diseased branch and the green foliage of the normal branches was striking. In the Hoback Canyon of the Wyoming National Forest *Melampsorella* was found on both hosts, moderately heavy on *Picea* and rather light on *Abies*. This area was not very thoroughly investigated and the situation in the small area examined in the Hoback Canyon may not be typical for the entire Wyoming National Forest.

The interesting feature of infections in this general area is the prevalence of the species on *Abies* in the Teton area while immediately north in Yellowstone National Park and south in the Wyoming National Forest the form on *Picea* was dominant.

## MEDICINE BOW NATIONAL FOREST, WYOMING

This region proved to be very favorable for collecting and study due to the presence of the fungus and the respective hosts in quantity, and as a result this forest was studied rather intensively. The map (FIG. 3) and also the data in Tables I and II

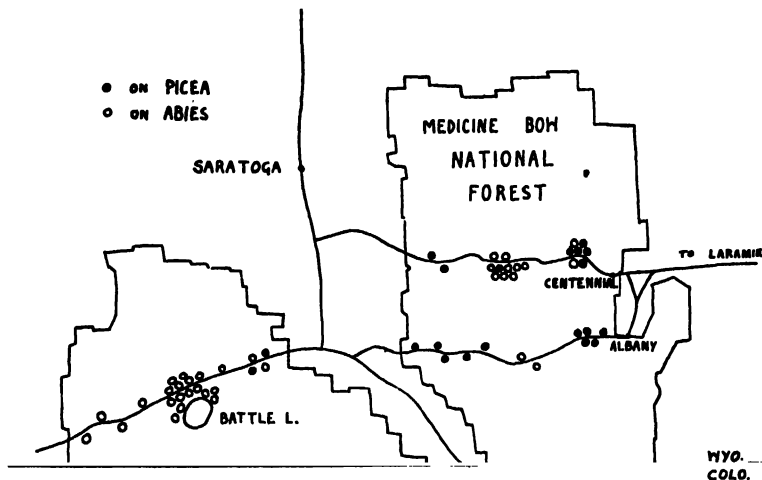


FIG. 3. Distribution of *Melampsorella* in the Medicine Bow National Forest, Wyoming. (See text for details.)

summarize the results obtained and demonstrate clearly the distribution patterns of these two species. In certain regions one species was definitely dominant while in other regions, often adjacent, the other species was abundant. For example, in the region of the University of Wyoming Summer Camp infections were heavy on *Picea*, scattered on *Abies*, yet in Libby Flats, a few miles west, the situation was completely reversed. West from Albany the *Picea* species was generally found in abundance.

In the western division of Medicine Bow National Forest, in the so-called Hayden Forest, infections were generally heavy on *A. lasiocarpa*, although a few were found on *Picea* between Encampment and the top of the Divide. In the region surrounding Battle Lake, an area was located where the species on *A. lasiocarpa* was in such abundance that it approached epidemic proportions. Witches' brooms occurred here in all sizes and in great numbers, each tree bearing one or more; one tree had 11 witches'

brooms all living and large, the largest being  $2\frac{1}{2}' \times 2' \times 2'$ . A young tree, 4' in height, had 8 witches' brooms on it, all young, 4 of them being year old infections. Many witches' brooms were on the main trunk; one broom  $3' \times 2' \times 2'$  was located 3' from the ground almost completely girdling it. A few of the brooms reached a diameter of 4'-5', somewhat greater than the usual run of the brooms on *Abies*, due possibly to 2 or more infections becoming confluent. Aecia were beginning to mature but had not yet broken open; however, the young sori gave the brooms a distinctly yellow cast. *A. concolor* and *P. Engelmanni* occurred in this region but they were free from the disease.

#### BLACK HILLS AND HARNEY NATIONAL FOREST, S. D.

*Melampsorella* was found on the Black Hills Spruce *P. glauca* var. *albertiana* in the Black Hills N.F. in the vicinity of the Black Fox and Deerfield Camp Grounds, and in the Harney N.F. along the Highway north of Custer. In these regions infections were numerous, sometimes several occurring on one tree and ranging in size from 2'-4' in diameter. The brooms had a distinctly reddish cast due to the aecia which were mature. The genus *Abies* is not represented in this area.

#### GUNNISON NATIONAL FOREST, COLORADO

Although this evidence was collected during the summers of 1939 and 1940 it is being added here because it shows striking differences in the distribution of the two species. In the region of Gothic the species on *Picea* is definitely dominant, the brooms on *P. Engelmanni* being large, conspicuous and numerous, often in great masses in the tops of the trees. While *Abies* occurs throughout the region infections on this host were rare; in two years a total of only 6 witches' brooms were found on *A. lasiocarpa*. For further details on the disease in this area and for photographs of typical infections reference should be made to a recent paper (6).

#### DISCUSSION

From the taxonomic standpoint distribution is sometimes important in the delineation of species. The obligate parasites

being completely dependent upon their hosts are thus limited in their distribution by the range of their hosts. *Melampsorella*, like other rusts, has developed a high degree of specialization on a specific group of plants particularly in the gametophytic phase on the coniferous hosts which has led to the formation of two distinct species. The two aecial hosts, *Picea* and *Abies*, being much alike in their ecological relationships, are very similar in their distribution, as for example, *P. Engelmanni* and *A. lasiocarpa*. It would be expected, therefore, that the two rusts would be very similar in their general distribution. However, it might be supposed since they have each developed through the centuries their own morphology, that differences might also exist in their physiology. This would be evident in the time of infection, conditions required for establishment of the infection, and for the continued growth of such infections, so that in a given area conditions might be more favorable for the development of one species, while in another area they might be more favorable for the development of the other. Such seems to be the case in *Melampsorella*. In every heavily infected area visited, one or the other species was found to be dominant, while in areas lightly infected it was often difficult to be sure which species was the more abundant, since only a small number could be examined. In a few cases such as in the Black Hills and in California only one of the two coniferous hosts was present, and therefore the evidence here would be of less significance.

In the forests of California, Oregon, Washington, the disease is not severe and occurs usually as isolated scattered infections, whereas in the Rocky Mountain States it is widely spread, abundant and in certain areas (Table II) of epidemic proportions. In these latter areas witches' brooms are found on all sizes of trees and in all stages of growth. One tree for example, 4' in height, had 2 witches' brooms, one of which completely surrounded the trunk and extended to within 6" of the tip. Other young trees have been found with 7-8 brooms upon them. The demands of such infections become very great when it is realized that each year the number of new infected branches is sharply increased, particularly when the broom has reached a diameter of one or more feet. The tree is thus handicapped in its struggle

for existence, and its growing period is probably greatly shortened. If the infection involves the terminal growing point, the tree becomes stunted and often dies prematurely. The probable effect of a large witches' broom girdling the main trunk would be to interfere greatly with normal translocation. It is a common sight to see a large tree, particularly of *Picea*, with a great mass of branches surrounding the trunk and the tree dead above the infections. On the basis of many observations on all sizes of trees infected in varying degrees, it would appear that light infections cause a relatively insignificant amount of damage, moderate infections result in some injury especially to young trees which may be prematurely killed, while heavy infections are always serious on both old and young trees, shortening the growing period of the former and usually killing the latter.

Another effect of a main trunk infection appears to be the gradual weakening of the tree at that point. In the Grand Canyon National Park many old trees were observed which had been snapped off at a point marked by several old witches' brooms, suggesting that the rust mycelium had gradually weakened the trunk at that point making it susceptible to breakage. In the opinion of the writer this disease is sometimes more serious than has been generally recognized.

A few cases of growing point escapes were observed similar to those reported in a previous paper (6). The growing point usually of a lateral branch, after being infected, outgrows the infection leaving the mycelium in a definite area on the branch, from which by supernumerary secondary buds, small brooms are formed at the nodes. It is not known whether the mycelium is capable of invading healthy tissue of the older part of the branch, but it seems doubtful. On most brooms the mycelium invades only the season's growth, since it is systemic in the meristematic regions. Only one broom was found which contained a mixture of healthy and diseased branches. The broom was large and conspicuous but was greenish in color due to the large number of healthy leaves. Many of the branches appeared to be perfectly healthy but when examined closely were found to have one or two small infected leaves. Some of the branches were lacking in leaves, indicating infection, but the season's branches were nor-

mal; in one case involving 3 new shoots arising from one branch, 2 were infected and the other was free. On this same branch at another place all of the leaves were infected except one leaf at the base of the branch. On another branch which appeared healthy, that is the needles had been retained for the last 5 years, 5 or 6 of the leaves were found to bear pycnia. This was the only broom found where all of the buds were not systemically infected. In this case the fungus had failed to become established, and the host may be simply outgrowing the fungus. The condition was evidently a local one since the same tree bore two other brooms which were typical in every respect.

Apical dominance appears to be present in the brooms on *Picea*, the terminal branch often growing 6"-8" during the season while the supernumerary lateral branches are much shorter, thus giving rise to a diffuse type of broom, with many prominent irregular branches, which sometimes reach a diameter of 4'-6' or become even larger. In the form on *Abies* apical dominance is apparently lacking and the lateral buds, which seem to be more numerous, make almost as much growth as the terminal bud, resulting in a very compact type of broom with a great many relatively uniform branches, rarely exceeding a diameter of 2'-3'. These differences found so consistently indicate clearly that these two types of witches' brooms are due to a fundamentally different manner of growth.

Geotropic disturbances are evident in both types of infection. Normally, lateral branches are transversely geotropic while the terminal bud of the main trunk is negatively geotropic. It has been noted many times on both *Picea* and *Abies* that the infected branches become at once negatively geotropic. In one case on a lateral branch of *A. lasiocarpa* in the Uintah National Forest the infection stood out sharply at right angles to the branch projecting upwards about 8". An interesting specimen was collected on *P. Engelmanni* in the Medicine Bow National Forest. The infection was about 1½' high, very regular and compact. It appeared to be growing directly on the ground but when examined closely was found to be at the end of a long lateral branch. This branch originated at the base of a tree about 6' distant and was completely covered with leaves and debris.

This was a very conspicuous example of altered tropism since the broom was growing at an almost perfect right angle to the lateral branch.

Conclusive proof of the existence of two species would be furnished by inoculations to the alternate hosts *Cerastium* and *Stellaria* and then inoculations back to the aecial hosts. During the summer of 1941 infection studies were commenced and are being continued, the results of which will be published later. At the present time it is not known if differences also exist in the uredo and telial stages of these two species, nor is it known exactly when infection to *Abies* and *Picea* takes place. The fact that the diploid sporophytic mycelium on *Cerastium* is also systemic and perennial increases greatly the opportunities for successful infections. An attempt is being made to work out the species of *Cerastium* and *Stellaria* which harbor the alternate stage and to obtain comparative material. Preliminary experiments seem to indicate that the same species of *Cerastium* harbor both species of *Melampsorella*, which confirms Weir and Hubert's observation (8) although Arthur (1) considers this to be improbable due to the unlike nature of the pycnia. The situation is comparable to that of *Cronartium coleosporioides* where the aecia assume "three fairly distinguishable forms which have been shown by culture to produce uredia and telia of identical appearance on the same species of *Castilleja*" (2). The three forms were treated first by Arthur as distinct species, later as varieties (2). The very great differences in the morphology and physiology of the haploid stages of *Melampsorella* constitute adequate evidence for the establishment of two species even if the diploid stages should prove to be identical.

#### SUMMARY

Further evidence for the existence of two species of *Melampsorella* was obtained from a study of their distribution. Many areas in the Western States were visited during the summer of 1941, and in the forests where both hosts and the disease were found detailed studies were made on the distribution of the two forms. Seventy-five collections and over 150 detailed observations were made. In practically every area visited one or the



other species was found to be dominant, even though both hosts were abundant, indicating that these two species differ in their physiology as well as in their morphology. Two distinct distribution patterns were thus obtained.

The disease was collected in the following National Forests: Uintah N.F., Wasatch N.F., Powell N.F., Utah; Kaibab N.F., Ariz.; Mt. Hood N.F., Ore.; Teton N.F., Wyoming N.F., Medicine Bow N.F., Wyo.; Harney N.F., Black Hills N.F., S. D.; and in the following National Parks: Grand Canyon N.P., Ariz.; Sequoia N.P., Yosemite N.P., Calif.; Crater Lake N.P., Ore.; Mt. Rainier N.P., Wash.; Glacier N.P., Mont.; Yellowstone N.P. and Grand Teton N.P., Wyo.

In the forests of the Rocky Mountain States where *Picea* and *Abies* are abundant the disease was found to be more severe than heretofore believed. Many trees were found to be partially or completely dead; many were dwarfed or stunted. In some areas in Wyoming the disease occurred in such abundance that it was considered to be of epidemic proportions.

Trunk infections were found to be particularly harmful. In the Grand Canyon National Park many older trees were found which had been broken off evidently due to weakening of the main trunk at that point. Trunk infections of young trees soon cause their death.

Differences in growth habits which produce a dense, compact broom on *Abies* and an irregular diffuse broom on *Picea* were found to be a constant and fairly reliable character, and are believed to be due to apical dominance which is present in the species on *Picea* and absent in the species on *Abies*.

OTTAWA UNIVERSITY,  
OTTAWA, KANSAS

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# A TAXONOMIC STUDY OF THE GENUS *HANSENULA*<sup>1</sup>

C. L. BEDFORD<sup>2</sup>

Since yeasts are of importance in several unrelated fields of investigation a great deal of confusion has arisen in their classification. While the classification systems of Stelling-Dekker (1931) for ascospore-forming yeasts and of Lodder (1932, 1934) for anascosporogenous yeasts have gained almost complete universal acceptance and are a vast improvement over the confusion which preceded them, they are still incomplete and difficult to use. The placing of a given strain in a particular genus is not easy and even more difficulty is experienced in differentiating between the species belonging to a given genus.

The purpose of this investigation has been to obtain more definite information concerning the morphology and taxonomy of the closely related species of the genus *Hansenula*.

## EXPERIMENTAL PROCEDURE

In this investigation a study was made of 100 cultures of yeast obtained as species of *Hansenula* from various sources in the United States, Europe, Asia and South Africa with 14 species of *Hansenula* represented. These cultures were obtained from the collection of yeasts of the Fruit Products Laboratory, University of California, Berkeley, and are listed in Table I.

The morphological characteristics were determined essentially by the methods described by Stelling-Dekker (1931). Cell size was determined on cultures grown in 15° Balling unhopped beer wort and in synthetic medium (0.1 per cent  $\text{KH}_2\text{PO}_4$ , 0.1 per cent  $(\text{NH}_4)_2\text{SO}_4$ , 0.05 per cent  $\text{MgSO}_4$  and 5 per cent glucose). Observations were also made on cultures grown in 15° Balling wort agar and wort gelatin. For spore formation carrot, beet and

<sup>1</sup> This paper is part of a thesis submitted in partial satisfaction of requirements for the degree of Doctor of Philosophy, University of California.

<sup>2</sup> Now with the Department of Horticulture, State College of Washington, Pullman.

potato wedges, Gorodkova agar and gypsum blocks were used. For those cultures that did not sporulate on these media, other media as grape, prune and cherry juice and agar, liquid wort and wort agar, synthetic medium with 10 per cent glucose, lactose and sucrose alone and with the acids tartaric, citric and malic in concentrations of 0.1 per cent were tried. The method of Stantial (1928, 1935) was also used.<sup>3</sup> All sporulation tests were stored

TABLE I

| Number | Culture Studied                         | Source                |            | Writer's Identification                     |
|--------|---|-----------------------|------------|---|
|        |   | Person                | Country    |   |
| 1      |   |                       | India      | <i>H. saturnus</i>                          |
| 2      | Grapes                                  | Mrak                  | California |   |
| 3      | Grapes                                  | Mrak                  | California | <i>H. anomala</i>                           |
| 5      | <i>H. saturnus</i>                      | A.T.C.C. <sup>4</sup> |            | <i>H. saturnus</i>                          |
| 6      | <i>H. anomala</i>                       | A.T.C.C.              |            | <i>H. anomala</i>                           |
| 7      | <i>H. anomala</i>                       | Takahashi             | Japan      | <i>H. anomala</i>                           |
| 8      | Concentrated sugar-egg mixture          | Baker                 | California | <i>H. subpelliculosa</i>                    |
| 9      | "                                       | Baker                 | California | <i>H. subpelliculosa</i>                    |
| 10     | "                                       | Baker                 | California | <i>H. subpelliculosa</i>                    |
| 11     | "                                       | Baker                 | California | <i>H. subpelliculosa</i>                    |
| 13     | <i>H. Schneggii</i>                     | C.B.S. <sup>5</sup>   | Holland    | <i>H. Schneggii</i>                         |
| 14     | <i>H. anomala</i> var. <i>sphaerica</i> | C.B.S.                | Holland    | <i>H. anomala</i>                           |
| 17     | Bottled white wine                      | Funch                 | California | <i>H. anomala</i>                           |
| 19     | Simple sirup 31° Be.                    | Mrak                  | California | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 20     | Simple sirup 31° Be.                    | Mrak                  | California | <i>H. anomala</i>                           |
| 21     | Simple sirup 31° Be.                    | Mrak                  | California | <i>H. anomala</i>                           |
| 22     | Simple sirup 31° Be.                    | Mrak                  | California | <i>Brettanomyces bruxellensis</i>           |
| 23     | Simple sirup 31° Be.                    | Mrak                  | California | <i>H. anomala</i>                           |
| 24     | Simple sirup 31° Be.                    | Mrak                  | California | <i>H. anomala</i>                           |
| 25     | Simple sirup 31° Be.                    | Mrak                  | California | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 26     | Sugar sirup                             | Mrak                  | California | <i>H. anomala</i>                           |
| 27     | Soil                                    | Cruess                | California |   |
| 28     | Grapes                                  | Mrak                  | California | <i>Candida Krusei</i>                       |
| 29     |   | Mrak                  | California | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 30     | Olives                                  | Vaughn                | California | <i>Pichia fermentans</i>                    |
| 31     | Soil                                    | Mrak                  | California | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 32     | Sweet wine                              | Mrak                  | California | <i>H. anomala</i>                           |
| 33     | Apricot extract                         | Mrak                  | California | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 34     | Grapes                                  | Mrak                  | California | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 36     | Grape juice                             | Mrak                  | California |   |
| 37     | <i>Willia</i> sp. No. 83                | Kroemer and Krumholz  | Holland    | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 38     | <i>H. anomala</i>                       |                       | Germany    | <i>H. anomala</i>                           |
| 39     | <i>H. anomala</i> I                     |                       | Germany    | <i>H. anomala</i>                           |
| 40     | <i>H. anomala</i> II                    |                       | Germany    | <i>Pichia fermentans</i> var. <i>rugosa</i> |
| 41     | <i>H. saturnus</i>                      |                       | Germany    | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 42     | <i>H. panis</i>                         | Castelli              | Italy      | <i>H. anomala</i>                           |
| 43     | Dried prunes                            | Mrak                  | California | <i>H. anomala</i>                           |
| 45     | Dried prunes                            | Mrak                  | California | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 46     | Dried prunes                            | Mrak                  | California | <i>Candida Krusei</i>                       |
| 47     | Dried prunes                            | Mrak                  | California | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 48     | Dried figs                              | Mrak                  | California | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 49     | Dried pears                             | Mrak                  | California | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 50     | Dried apricots                          | Mrak                  | California | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 51     | Dried prunes                            | Mrak                  | California | <i>H. anomala</i> var. <i>sphaerica</i>     |
| 52     | Sugared dried prunes                    | Mrak                  | California | <i>H. anomala</i>                           |
| 53     | Dried prunes                            | Eau No. 190           | California | <i>Pichia fermentans</i>                    |
| 54     | Prune debris                            | Mrak                  | California | <i>Pichia fermentans</i>                    |
| 55     | Dehydrated prunes                       | Mrak                  | California | <i>H. subpelliculosa</i>                    |

<sup>3</sup> This study was made by B. L. Smith.

<sup>4</sup> A.T.C.C. American Type Culture Collection, Washington, D. C.

<sup>5</sup> C.B.S. Centraalbureau voor Schimmelkulturs, Bairn, Holland.

TABLE I—Continued

| Number | Culture Studied                          | Source        |            | Writer's Identification                    |
|--------|--|---------------|------------|--|
|        |  | Person        | Country    |  |
| 56     | Dried prunes                             | Mrak          | California | <i>H. subpelliculosa</i>                   |
| 57     | Dried prunes                             | Mrak          | California | <i>H. subpelliculosa</i>                   |
| 58     | Dried prunes                             | Mrak          | California | <i>H. subpelliculosa</i>                   |
| 59     | Dried prunes                             | Mrak          | California | <i>H. subpelliculosa</i>                   |
| 60     | Dried prunes                             | Mrak          | California | <i>H. subpelliculosa</i>                   |
| 61     | Dried prunes                             | Mrak          | California | <i>H. subpelliculosa</i>                   |
| 62     | Dried prunes                             | Mrak          | California | <i>H. anomala</i> var. <i>sphaerica</i>    |
| 63     | Dried prunes                             | Mrak          | California | <i>H. anomala</i>                          |
| 64     | Dried prunes                             | Mrak          | California | <i>H. anomala</i>                          |
| 65     | Dried prunes                             | Mrak          | California | <i>H. subpelliculosa</i>                   |
| 66     | Sugared dried prunes                     | Mrak          | California | <i>H. anomala</i> var. <i>sphaerica</i>    |
| 67     | Sugared dried figs                       | Mrak          | California | <i>H. anomala</i>                          |
| 68     | <i>H. saturnus</i>                       |               | Poland     | <i>H. saturnus</i>                         |
| 69     | <i>H. anomala</i>                        |               | Poland     | <i>Pichia chodati</i>                      |
| 70     | <i>H. saturnus</i>                       | Winge No. 64  | Holland    | <i>H. saturnus</i>                         |
| 71     | Arnold sirup                             | Mrak          | California | <i>H. anomala</i> var. <i>sphaerica</i>    |
| 72     | Arnold sirup                             | Mrak          | California | <i>Candida Guilliermondi</i>               |
| 73     | Arnold sirup                             | Mrak          | California | <i>Torulopsis</i> sp.                      |
| 75     | <i>H. nivea</i>                          | Castelli      | Italy      | <i>H. anomala</i>                          |
| 76     | Arnold sirup                             | Mrak          | California | <i>Zygothansenula californica</i>          |
| 77     | Fountain sirup                           | Mrak          | California | <i>Torulopsis</i> sp.                      |
| 78     | <i>H. Ciferri</i>                        | Lodder        | Holland    | <i>H. Ciferri</i>                          |
| 79     | Arnold sirup                             | Mrak          | California | <i>H. anomala</i>                          |
| 81     | Arnold sirup                             | Mrak          | California | <i>H. anomala</i> var. <i>sphaerica</i>    |
| 82     | Arnold sirup                             | Mrak          | California | <i>Candida Guilliermondi</i>               |
| 84     | <i>H. anomala</i> var. <i>sphaerica</i>  | C.B.S.        | Holland    | <i>H. anomala</i> var. <i>sphaerica</i>    |
| 85     | <i>H. anomala</i> var. <i>sphaerica</i>  | C.B.S.        | Holland    | <i>H. anomala</i> var. <i>heteromorpha</i> |
| 86     | <i>H. anomala</i>                        | Winge No. 119 | Holland    | <i>H. anomala</i> var. <i>sphaerica</i>    |
| 87     | <i>Hansenula</i> sp.                     | Winge No. 94  | Holland    | <i>H. anomala</i> var. <i>longa</i>        |
| 88     | <i>H. anomala</i> var. <i>longa</i>      | C.B.S.        | Holland    | <i>H. anomala</i> var. <i>longa</i>        |
| 89     | <i>H. anomala</i> var. <i>productiva</i> | C.B.S.        | Holland    | <i>H. anomala</i> var. <i>longa</i>        |
| 90     | <i>H. javanica</i>                       | C.B.S.        | Holland    | <i>H. anomala</i> var. <i>sphaerica</i>    |
| 91     | <i>H. anomala</i> var. <i>robusta</i>    | C.B.S.        | Holland    | <i>H. anomala</i> var. <i>longa</i>        |
| 92     | <i>H. panis</i>                          | C.B.S.        | Holland    | <i>H. anomala</i> var. <i>longa</i>        |
| 93     | <i>H. saturnus</i>                       | C.B.S.        | Holland    | <i>H. saturnus</i>                         |
| 94     | <i>H. lambica</i>                        | C.B.S.        | Holland    | <i>H. lambica</i>                          |
| 95     | <i>H. nivea</i>                          | C.B.S.        | Holland    | <i>H. anomala</i> var. <i>longa</i>        |
| 96     | <i>Zygothansenula californica</i>        | Lodder        | Holland    | <i>Zygothansenula californica</i>          |
| 97     | <i>H. suaveolens</i>                     | C.B.S.        | Holland    | <i>H. suaveolens</i>                       |
| 98     | Olives                                   | Vaughn        | California | <i>Candida Krusei</i>                      |
| 99     | Olives                                   | Vaughn        | California | <i>Candida Krusei</i>                      |
| 101    | Olives                                   | Vaughn        | California | <i>Candida Krusei</i>                      |
| 102    | Olives                                   | Vaughn        | California | <i>Candida Krusei</i>                      |
| 103    | Olives                                   | Vaughn        | California | <i>Pichia Kluyveri</i>                     |
| 104    | <i>Hansenula</i> sp.                     | Niehaus       | Africa     | <i>H. anomala</i>                          |
| 105    | <i>H. javanica</i>                       | C.B.S.        | Holland    | <i>H. anomala</i> var. <i>longa</i>        |
| 106    | <i>H. anomala</i>                        | C.B.S.        | Holland    | <i>H. anomala</i> var. <i>heteromorpha</i> |
| 107    | Olive brine 58° S.                       | Douglas       | California | <i>H. anomala</i> var. <i>sphaerica</i>    |
| 108    | Olive brine 28° S.                       | Douglas       | California | <i>H. anomala</i> var. <i>sphaerica</i>    |
| 109    | Green olive tank                         | Douglas       | California | <i>H. anomala</i> var. <i>sphaerica</i>    |
| 110    | Fresh water olive tank                   | Douglas       | California | <i>H. anomala</i>                          |

at a temperature of 20–25° C. for more than six weeks if necessary. Colors were reported according to the nomenclature of Ridgway (1912) and cultural characteristics according to the customary terminology used by bacteriologists, e.g. Levine (1933). Pseudomycelium formation was determined by the method of Rivalier and Seydel (1932) using their medium and wort agar. Fermentation tests were made using the Durham (1898) tube

technique. The yeast juice medium described by Stelling-Dekker (1931) was used in the fermentation tests. The quantitative method of van Iterson-Kluyver (see Stelling-Dekker) was used when doubtful results were obtained and to determine the amount of raffinose fermented.

The ability of the organisms to utilize the various carbon and nitrogen compounds was determined by growth of the organisms and utilization of the compounds in a liquid synthetic medium.  $(\text{NH}_4)_2\text{SO}_4$  and glucose were replaced by the compounds to be studied. The nitrogen compounds were added in concentrations sufficiently low (5 mg. N per 100 ml.) so that the amount as well as the utilization could be determined quantitatively.

The production of esters was determined qualitatively and quantitatively using grape juice and synthetic medium with glucose and ethyl alcohol. Yeast juice plus glucose was also used but ester production was only determined qualitatively.

#### SYSTEMATIC TREATMENT

A number of investigators have contributed to the study of the taxonomy and morphology of the genus *Hansenula*. The generic characters of the genus *Hansenula* Sydow have been defined by Hansen (1904), Guilliermond (1928, 1936) and Stelling-Dekker (1931).

Hansen (1904) characterized the genus as yeasts forming a film on sugar nutrient media. Spores hat or lemon shaped, smooth-walled with one membrane and a very prominent ledge. Most species form esters; a few do not ferment. Germination of spores by budding.

Stelling-Dekker (1931) defined the genus as follows: Cells of various shapes, round, oval or elongated; vegetative reproduction by many-sided budding, often clusters of buds. A pellicle, dry on account of the co-mixture of air, and dull, formed at once in sugar nutrient media. Spores hat-shaped, oblate, globular or Saturn-shaped. Vigorous fermentation. Nitrate assimilation positive; with ethyl alcohol a vigorous growth with formation of a membrane. Esculin cleavage positive.

Guilliermond (1936) recently described the genus as yeasts with oval or elongated, rarely round cells, occasionally rudiments

of mycelium. Asci formed with conjugation; 1-4 ascospores having the aspect of hats or surrounded by a projecting collar. In certain forms (*H. saturnus*) conjugation between ascospores or more generally between the first cells issued by their budding yields zygospores, initial point of numerous generations of diploid cells transformed then to asci. Fungi develop initially in liquid medium as a pellicle. Oxidation and occasionally fermentation.

On the basis of this investigation the genus has been redefined as follows: Cells of various shapes, spherical, oval or elongated. Vegetative reproduction by many-sided budding. Pellicle formed on liquid medium, well-developed or very slight. Conjugation may or may not immediately precede ascospore formation. Spores hat- or Saturn-shaped. Vigorous fermentation. Nitrate and nitrite assimilation positive (auxanogram method of Beijerinck). Growth with ethyl alcohol. Esculin and salicin hydrolyzed.

The genus is divided into two subgenera, namely *Hansenula* and *Zygothansenula* following Klocker's (1924) procedure for the genus *Pichia*. This is also in agreement with the view expressed by Lodder (1932).

The definition of the subgenus *Hansenula* is as for the genus *Hansenula* with the added characteristic that no conjugation immediately precedes ascospore formation.

The definition of the subgenus *Zygothansenula* is as for the genus *Hansenula* with the added characteristic that conjugation immediately precedes ascospore formation.

In 1931 Stelling-Dekker carefully studied the species of *Hansenula* described by the various authors and accepted, as valid species or varieties, the following, which also includes those recently described by Lodder (1932) and Castelli (1937). *H. saturnus* (Klocker) Sydow, *H. anomala* (Hansen) Sydow, *H. anomala* var. *sphaerica* (Naegeli) Dekker, *H. anomala* var. *productiva* Dekker, *H. anomala* var. *longa* Dekker, *H. anomala* var. *robusta* Dekker, *H. javanica* (Groenewege) Dekker, *H. Schneggii* (Weber) Dekker, *H. Ciferri* Lodder, *H. suaveolens* (Klocker) Dekker, *H. panis* Castelli, *H. nivea* Castelli and *Zygothansenula californica* Lodder. Two species, *H. Wichmanni* described by

Zikes (1906) and *H. fermentans* described by Verona and Valleggi (1933), are not available as they have been lost. Since Stelling-Dekker's treatment of the genus *Hansenula* is more complete than any other systematic treatment of the genus it is the logical system to follow. At the present time several species and varieties are separated by minor characters and it is very difficult to distinguish these species and varieties with certainty. Thus in this investigation an attempt has been made through a more complete morphological study to obtain criteria whereby the species or varieties can be identified more easily.

The cultures studied showed considerable similarity in morphological characteristics with the exception of cell size. The slant cultures, giant colonies, films, spore formation, and pseudomycelia are all very similar and as a whole give no sound basis for the separation of the various varieties. Therefore, with the exception of a few cultures, cell size, as used by Stelling-Dekker (1931), appears to be the only possible means at the present time for the separation of varieties or species. This is not entirely satisfactory as when different media are used for growth and measurement of the cells considerable variations are obtained.

In his fundamental researches Hansen used hopped wort whereas other research workers have undoubtedly used unhopped wort, although records are frequently lacking. This is of fundamental importance as the presence or absence of hop extract in the medium will influence the shape and size of the individual cells. The manner in which the wort is made will also have an influence on the shape and size of the cells. It should be noted that Stelling-Dekker in her excellent work described exactly the method used for making unhopped wort.

The examination of the cultures in this study showed some variation in cell size in different lots of liquid wort and therefore liquid synthetic medium was used to determine whether this variation could be eliminated. The shape and size of the cells in synthetic medium, in some cases, varied considerably from those formed in liquid wort, e.g. a number of cultures that form elongate cells in liquid wort form only spherical and oval cells in synthetic medium. However, the results obtained were more



consistent and it seems that the use of a synthetic medium for the measurement of cells would be more suitable for this genus than liquid wort as its use would eliminate the variations that occur in natural media, such as liquid wort, due to the different methods of preparation and variations in material used for its preparation and would facilitate the comparing of results obtained by various investigators as pure chemicals are available to all for its preparation.

The physiological studies show, as a whole, very little difference between the species of *Hansenula* with the exception of their fermentative powers. The cultures have therefore been grouped for taxonomic treatment on the basis of cell size in synthetic medium and fermentative characteristics in most cases.

#### HANSENULA ANOMALA (Hansen) Sydow.

Syn: *H. anomala* var. *sphaerica* (Naegeli) Dekker (14), *H. panis* Castelli (42) and *H. nivea* Castelli (75).

Twenty-three cultures were placed in this species.

Cells spherical, oval and elongate in 3 and 10 day liquid synthetic medium. Dimensions of cells from film on synthetic medium  $1.75-6 \times 2.35-19 \mu$  at 3 days and  $1.75-8 \times 2.35-19 \mu$  at 10 days. Spores hat-shaped,  $1.75-2.35 \times 2.35-3 \mu$ , 1-4 per ascus. Films form on liquid medium within 48 hours; on synthetic medium smooth to slightly rugose, tending to become farinose; on liquid wort smooth to rugose. Sediment increases with time. 60 day wort gelatin giant colonies smooth to farinose, occasionally actinomorphous stripes in the colony, flat to umbonate, edges entire to undulate, dull, buff to white. 60 day wort agar slants, smooth to vesicular, slopes smooth to slightly contoured, raised to convex, edges entire to lobate-lobulate, periphery plumose, dull to glistening, light buff. 30 day synthetic agar slants, slightly rugose to rugose, convex, edges lobate-lobulate, dull, light ivory. Pseudomycelia of elongate cells on wort agar with spherical and oval blastospores. Ferments glucose, fructose, mannose, sucrose, maltose, galactose, and raffinose (1/3). Does not ferment arabinose, xylose, lactose, glycerol, mannitol or dextrin. Nitrate and nitrite assimilated, sarcosine not assimilated. Forms ester in grape juice, synthetic medium with glucose or ethyl alcohol, yeast juice with glucose. Ethyl alcohol utilized. Esculin and salicin hydrolyzed.

Cultures 26 and 29 do not utilize guanidine as a nitrogen source and 39 does not ferment galactose. However these differences are not sufficient to justify the separation of these cultures as varieties or types.

HANSENULA ANOMALA var. SPHAERICA (Naegeli) Dekker.

Syn: *H. anomala* (Hansen) Sydow (86) and *H. javanica* (Groenewege) Dekker (90).

Twenty-four cultures were placed in this variety.

This variety is similar to *H. anomala* except cells on liquid synthetic medium, spherical to oval, occasionally somewhat elongate. Dimensions of cells from films,  $1.75-7 \times 2.35-10 \mu$ , few up to  $12 \mu$ .

In this group cultures 19, 33, 34, 41, 45, 47, 48, 49 and 86 do not utilize guanidine as a nitrogen source. Cultures 45, 48, and 50 do not assimilate  $\alpha$  methyl glucoside. These, however, do not justify the establishment of new varieties.

HANSENULA ANOMALA var. LONGA Dekker.

Syn: *H. anomala* var. *productiva* Dekker (89), *H. anomala* var. *robusta* Dekker (91), *H. panis* Castelli (92), *H. nivea* Castelli (95) and *H. javanica* (Groenewege) Dekker (105).

Six cultures were placed in this variety.

Cells grown in liquid synthetic medium, spherical, oval to very elongate, chains of elongate cells at 3 and 10 days. Dimensions of cells from films at 3 and 10 days,  $1.25-5 \times 2.35-30 \mu$ . Films on liquid wort rugose to folded, on synthetic medium smooth to slightly rugose. 60 day wort gelatin giant colonies, smooth to farinose, flat to umbonate, edges entire to undulate, dull, buff to white. 60 day wort agar slants smooth to rugose or verrucose, flat to convex, slopes slightly vesicular to rugose, edges entire to lobate-lobulate, periphery plumose, dull, light buff. 30 day synthetic agar slants, rugose, convex, edges entire to lobate, light ivory. Other characteristics as *H. anomala*.

Culture 87 differs from the above in that the film on liquid wort is smooth with 1-4 folds at 3 and 10 days. 30 day synthetic agar slant light rose in color. This, however, is not sufficient to justify the establishment of a new variety.

**Hansenula anomala** var. **heteromorpha** var. nov.

Syn: *H. anomala* var. *sphaerica* (Naegeli) Dekker (86) and *H. anomala* (Hansen) Sydow (106).

This variety is similar to *H. anomala* var. *longa* except culture 106 forms pseudomycelia of heteromorphic cells in liquid synthetic medium at 3 and 10 days.

Cells spherical, oval, oblong, pyriform and slender elongate. Few free cells. Culture 85 at 3 days in liquid synthetic medium, cells spherical, oval to elongate,  $2.35\text{--}4.7 \times 3.5\text{--}16.5 \mu$  at 10 days as 106 but with free cells.

The difference between the two cultures is the time necessary for the formation of pseudomycelia and this is not sufficient for their separation.

**Hansenula subpelliculosa** sp. nov.

Eleven cultures were placed in this species. These were isolated from concentrated sugar-egg mixture and dried prunes.

Cells spherical to oval at 1, 3, 10 days in liquid wort and in liquid synthetic medium at 3 and 10 days. Dimensions of cells  $2.2\text{--}7 \times 2.2\text{--}9 \mu$ , occasional large spherical cells  $9.5\text{--}11 \times 9.5\text{--}11 \mu$ . Spores hat-shaped,  $1.75\text{--}2.35 \times 2.35\text{--}3 \mu$ , 1-2, 3-4 per ascus. Films on liquid wort and synthetic medium very thin or none, ring formed in 10 days. Sediment increases with time. 60 day wort gelatin giant colonies flat to slightly umbonate, smooth to slightly contoured, border undulate, dull, buff. Culture 60 differs in being rugose. 60 day wort agar slants convex, flattened surface smooth to slightly vesicular or verrucose, slopes slightly contoured, border entire to lobate-lobulate, glistening, periphery plumose, light buff. 30 day synthetic agar slants smooth, glistening, light ivory. Pseudomycelia of elongate cells on wort agar with spherical and oval blastospores. Ferments glucose, fructose, mannose, maltose, sucrose and raffinose (1/3). Does not ferment galactose, lactose, xylose, arabinose, glycerol, mannitol or dextrin. Nitrate and nitrite assimilated (auxanogram method). Forms ester in grape juice and yeast juice with glucose. Growth in synthetic medium very slow and poor. Ethyl alcohol utilized. Esculin and salicin hydrolyzed.

Cultures 8, 9, 10, 11, 55 and 58 do not utilize galactose. Culture 61 differs in that 60 day wort gelatin giant colony rugose, alveolate, umbonate, border undulate, dull, buff and it does not

ferment maltose. These differences are not sufficient for the establishment of a new variety.

The lack of a good film on liquid wort and very poor growth in synthetic medium differentiates this species from the others and justifies the establishment of a new species.

#### HANSENULA SATURNUS (Klocker) Sydow.

Five cultures were placed in this species.

Cells spherical to oval at 1, 3 and 10 days in liquid wort and synthetic medium. Dimensions of cells from films on liquid wort  $2.5-7 \times 3.5-8 \mu$  at 1 and 3 days,  $3-8 \times 3.5-8 \mu$  at 10 days; on synthetic medium  $2.35-8 \times 3-9 \mu$  at 3 and 10 days. Giant cells in 3 and 10 day synthetic medium  $7-11 \times 8.5-12 \mu$ . Clusters (sprossverbände) in synthetic medium at 3 and 10 days. Spores Saturn-shaped,  $1.75-3 \times 2.35-3 \mu$ , 1-2 per ascus. Films on liquid wort and synthetic medium at 48 hours, rugose on wort and smooth on synthetic medium; becomes rugose on synthetic medium at 6 days. Sediment increases with time. 60 day wort gelatin giant colonies mostly smooth with irregular farinose and rugose surface markings, dull, buff with surface markings chalky white. 60 day wort agar slants convex, flattened surface slightly vesicular, slopes slightly contoured, borders lobate-lobulate, dull, light buff. 30 day synthetic agar slants convex, rugose, borders lobate-lobulate, dull, light ivory. Ferments glucose, fructose, mannose, sucrose, and raffinose (1/3). Does not ferment galactose, maltose, lactose, xylose, mannitol, glycerol or dextrin. Nitrate, nitrite and sarcosine assimilated, succinimide not assimilated. Does not utilize galactose, maltose, erythritol,  $\alpha$  methyl glucoside, phloridzin and malonic acid. Forms a small amount of ester in grape juice, synthetic medium with glucose or ethyl alcohol, yeast juice with glucose. Ethyl alcohol utilized. Esculin and salicin hydrolyzed.

#### HANSENULA SUAVEOLENS (Klocker) Dekker (97).

Cells spherical to oval in liquid wort and synthetic medium at 1, 3, 10 and 3 and 10 days respectively. Dimensions of cells from films on liquid wort  $2.5-5.25 \times 3.5-8 \mu$  at 1, 3 and 10 days; from films on synthetic medium  $3.5-7 \times 3.5-7 \mu$ . Clusters (sprossverbände) in synthetic medium at 10 days. No sporulation obtained. Films on liquid wort and synthetic medium within 24 hours, rugose on liquid wort and smooth on synthetic medium. Sediment increases with time. 60 day wort gelatin giant colonies, flat to slightly raised, smooth, dull, buff. 60 day

wort agar slants raised, center finely verrucose, borders lobate-lobulate, dull, periphery plumose, light buff. 30 day synthetic agar slants convex, slightly rugose, borders lobulate, dull, light ivory. Fermentation of glucose, fructose, mannose, sucrose and raffinose (1/3). Does not ferment galactose, maltose, lactose, xylose, arabinose, mannitol, glycerol or dextrin. Nitrate and nitrite assimilated, sarcosine and succinimide not assimilated. Does not utilize arabinose, erythritol,  $\alpha$  methyl glucoside, phloridzin, citric or malonic acids. Forms little ester. Ethyl alcohol utilized. Esculin and salicin hydrolyzed.

HANSENULA CIFERRI Lodder (78).

Cells spherical to oval in liquid wort and synthetic medium. Dimensions of cells from films on liquid wort  $3.5-8 \times 3.5-8 \mu$  at 1, 3 and 10 days; from films on synthetic medium  $2.35-6 \times 2.35-6 \mu$  at 3 and 10 days. Clusters (sprossverbände) in synthetic medium at 3 and 10 days. Spores hat-shaped,  $1.75-2.35 \times 2.35-3 \mu$ , 2-4 per ascus. Films on liquid wort and synthetic medium as islets in 2 days, complete in 4 days, smooth, thin. 60 day wort gelatin giant colonies with depressed center, edge corrugated, border undulate, moist, glistening, buff. Gelatin slightly liquefied in center. 60 day wort agar slant raised, center vesicular, slopes smooth, borders lobulate, dull, periphery slightly plumose, light buff. 30 day synthetic agar slant convex, smooth, borders lobulate, dull, light ivory. Pseudomycelia of elongate cells on wort agar, blastospores spherical and oval. Fermentation of glucose, fructose, mannose, galactose, sucrose, maltose, and raffinose (1/3). Does not ferment lactose, xylose, arabinose, glycerol, mannitol or dextrin. Nitrate and nitrite assimilated, cysteine, succinimide or guanidine not assimilated. Does not utilize citric, malic, malonic, acetic, lactic or fumaric acids. Forms slight amount of ester. Ethyl alcohol utilized. Esculin and salicin hydrolyzed.

During the culturing of this species in liquid wort it lost its ability to sporulate and to form elongate cells. However, a later examination of a six month old agar slant showed the presence of elongate cells. When this was transferred to liquid wort spherical, oval and a few elongate cells were present in the film. In the suspension and sediment very elongate cells ( $2.5-5 \times 10-29 \mu$ ) and pseudomycelia were found. On transferring this active culture to carrot wedges spores were observed in abundance after six days. Thus it appears that when successive

transfers are made in liquid wort the ability to form elongate cells is lost and also the ability to sporulate. The spores were formed in spherical and oval asci. Few elongate cells were present on carrot wedges.

*HANSENULA SCHNEGGII* (Weber) Dekker (13).

Cells spherical, oval to elongate in liquid wort and synthetic medium. Dimensions of cells from films on liquid wort  $2.5\text{--}3.5 \times 5.25\text{--}10.5 \mu$  at one day,  $1.25\text{--}5 \times 5.25\text{--}14 \mu$  at 3 and 10 days; from films on synthetic medium  $2.35\text{--}7.5 \times 4.5\text{--}14 \mu$  at 3 and 10 days. Pseudomycelia of elongate cells on wort agar, blastospores spherical and oval. No sporulation obtained. Film on liquid wort in 24 hours, rugose; on synthetic medium slightly rugose at 2 days, smooth at 6 and 12 days. Sediment increases with time. 60 day wort gelatin giant colonies flat, smooth, border undulate, dull, covered with farinose white layer. 60 day wort agar slant slightly convex, slightly rugose, border entire to slightly lobulate, dull, periphery plumose, chalky white. 30 day synthetic agar slant convex, slightly rugose, borders lobulate, dull, light ivory. Fermentation of glucose, fructose, mannose and maltose vigorous, sucrose slowly and galactose very slightly. Does not ferment raffinose, xylose, arabinose, glycerol, mannitol or dextrin. Nitrate and nitrite assimilated, guanidine, sarcosine or succinimide not assimilated. Forms ester in grape juice, synthetic medium with glucose or ethyl alcohol, yeast juice with glucose. Ethyl alcohol utilized. Esculin and salicin hydrolyzed.

The characteristics of this species agree with those given by Stelling-Dekker except that a weak fermentation of galactose was obtained.

*HANSENULA LAMBICA* (Kufferath) Dekker (94).

Cells spherical, oval to elongate, ogive. Dimensions of cells from films on liquid wort  $1.75\text{--}5 \times 5\text{--}24 \mu$  at 1 and 3 days,  $1.25\text{--}4 \times 3.5\text{--}28 \mu$  at 10 days; from films on synthetic medium  $1.75\text{--}5 \times 6\text{--}30 \mu$  at 3 and 10 days, mostly pseudomycelia of elongate cells at 10 days. No sporulation obtained. Pseudomycelia of elongate cells on wort agar, blastospores spherical and oval. Films on liquid wort thin, smooth, thick sectors. Film drops in large segments. On synthetic medium thin, farinose. Sediment increases with time. 60 day wort gelatin giant colonies flat, slightly rugose, border undulate, dull, buff. 60 day wort agar slant convex, vesicular, slope slightly contoured, border

lobate-lobulate, glistening, periphery plumose, light buff. 30 day synthetic agar slant convex, rugose, border lobulate, dull, light ivory. Fermentation of glucose, fructose, mannose, galactose, maltose, sucrose, raffinose (1/3). Does not ferment xylose, arabinose, glycerol, mannitol or dextrin. Nitrate and nitrite assimilated. Forms very little ester. Ethyl alcohol utilized. Esculin and salicin hydrolyzed.

The characteristics of this species agree with those given by Custers (1940) for *Brettanomyces lambicus*. However, as the original description of this species was not available we shall retain it as a species of the genus *Hansenula*.

#### ZYGOHANSENULA CALIFORNICA Lodder (76, 96).

Cells spherical to oval at 1, 3 and 10 days in liquid wort and synthetic medium. Dimensions of cells  $3.5-7 \times 3.5-7 \mu$ . Isogamous copulation; spores Saturn-shaped,  $1.5-2.35 \times 2-2.5 \mu$ , 1-4 per ascus. No sporulation obtained with culture 76. Films on liquid wort within 48 hours, thin, smooth. Sediment increases with time. No pseudomycelium. 60 day wort gelatin giant colonies flat, smooth, border slightly undulate, dull, buff. 60 day wort agar slants smooth, convex, slope contoured, border lobate-lobulate, glistening, periphery slightly plumose, light buff. 30 day synthetic agar slant, smooth, glistening, light ivory. Ferments glucose, fructose, mannose only. Does not ferment galactose, maltose, sucrose, raffinose, xylose, arabinose, glycerol, mannitol or dextrin. Nitrate and nitrite assimilated (auxanogram method). Growth in synthetic medium very poor. Forms very little ester. Ethyl alcohol utilized. Esculin and salicin hydrolyzed.

The other cultures included in this investigation have been identified as follows.

Six cultures were identified as species of the genus *Pichia*. Three cultures have been identified as *Pichia fermentans* Lodder and one as *Pichia Chodatii* (Zender) Dekker. Culture 40 differs from *Pichia fermentans* in its rugose film, rugose slant on synthetic medium and the formation of pseudomycelia in synthetic medium. It has therefore been designated as follows:

#### *Pichia fermentans* var. *rugosa* var. nov.

Cells spherical, oval and elongate, chains of elongate cells at 3 and 10 days in synthetic medium. Dimensions of cells from

films on liquid wort  $1.75-3.5 \times 3.5-9 \mu$  at 1 day,  $2.5-3.5 \times 5.25-14 \mu$  at 3 days,  $1.75-3.5 \times 3.5-12 \mu$  at 10 days; from films on synthetic medium  $2.3-4.7 \times 6.5-16 \mu$  at 3 and 10 days. Pseudomycelia of elongate cells in liquid synthetic medium at 3 and 10 days. Pseudomycelia of elongate cells on wort agar, no blastospores observed. No conjugation immediately preceding ascospore formation; spores hat-shaped,  $1.6-2 \times 2.2-3 \mu$ , 4 per ascus. Films on liquid wort and synthetic medium within 24 hours; on liquid wort very rugose and thick, on synthetic medium smooth at 3 days, then becomes rugose. Slight sediment. 60 day wort agar slant raised, finely vesicular, border lobulate, dull, wood brown. 30 day synthetic agar slant convex, rugose, border lobulate, dull, light rose. Ferments glucose, fructose and mannose only. Does not utilize maltose, galactose, arabinose, salicin, phloridzin,  $\alpha$  methyl glucoside, sodium pyruvate or erythritol. Nitrate, nitrite or succinimide not assimilated. No ester formation. Gelatin liquefied. Ethyl alcohol utilized. Esculin hydrolyzed.

Culture 103 differs from any of the described species of *Pichia* in its poor growth in synthetic medium and its formation of ester. This culture is designated as follows:

***Pichia Kluyveri* sp. nov.**

Cells spherical, oval in liquid wort. Dimensions of cells from films on liquid wort  $2-6 \times 3.5-10 \mu$  at 1, 3 and 10 days. Sporulation in 10 day old wort culture (15° Balling). No conjugation immediately preceding ascospore formation; spores hat-shaped,  $1.5-1.75 \times 2-2.5 \mu$ , 2-4 per ascus. No pseudomycelium. Films on liquid wort within 48 hours, rugose. 60 day wort gelatin giant colonies slightly rugose, flat, borders entire, dull, light grey. 60 day wort agar slant finely vesicular, flat, border lobulate, dull, cinnamon. Ferments glucose, fructose and mannose only. Does not utilize maltose, galactose or arabinose. Growth in synthetic medium very poor. Ammonium sulfate and peptone assimilated; nitrate, nitrite, urea or asparagin not assimilated (auxanogram method). Ester formed in grape juice and yeast juice with glucose. With ethyl alcohol slight sediment. Esculin hydrolyzed, salicin not hydrolyzed.

Six cultures were identified as belonging to the group *Candida Krusei* as defined by Langeron and Guerra (1938), two cultures belonging to the group *Candida Guilliermondi* of Langeron and Guerra, one culture as *Brettanomyces bruxellensis* Kufferath and



van Laer, and two cultures as species of the genus *Torulopsis*. One culture (77) is very similar to *Torulopsis californicus* Mrak and McClung (1940).

The following key has been formulated on the basis of this investigation. Observations made concerning variations in the cultures indicate, however, that this may prove to be only an elaboration of the work of Stelling-Dekker towards a more stable and reliable classification. The observations made concerning variation also indicate that a study of the homozygous or heterozygous nature of single cells or blastospores will be necessary before the limitation of species or varieties can be definitely established. At the present time it seems that future studies should be carried out using the methods employed by Snyder and Hansen (1940) in their studies of *Fusarium*.

#### KEY FOR THE SPECIES OF THE GENUS HANSENULA SYDOW

- 1a. Spores Saturn-shaped.....*H. saturnus*
- b. Spores hat-shaped..... 2
- 2a. Pellicle extremely thin and indistinct.....*H. subpelliculosa*
- b. Pellicle well developed and distinct..... 3
- 3a. Vigorous fermentation of glucose, sucrose and raffinose (1/3) only.....*H. suaveolens*
- b. Vigorous fermentation of glucose, maltose; ferments sucrose slowly, galactose weakly; no fermentation of raffinose.....*H. Schneggii*
- c. Vigorous fermentation of glucose, galactose, maltose, sucrose and raffinose (1/3)..... 4
- 4a. Cells spherical or oval, pellicle thin on synthetic medium, no pseudomycelium.....*H. Ciferri*
- b. Cells spherical, oval or elongate, pellicle well developed on synthetic medium, no pseudomycelium.....*H. anomala*
- c. Cells predominantly spherical, oval, occasionally shortly elongate on synthetic medium, pellicle well developed, no pseudomycelium.....*H. anomala* var. *sphaerica*
- d. Cells spherical, oval and elongate, pellicle well developed, pseudomycelium on synthetic medium..... 5
- 5a. Pseudomycelium of elongate cells, no ogive cells.....*H. anomala* var. *longa*
- b. Pseudomycelium of heteromorphic cells, no ogive cells...*H. anomala* var. *heteromorpha*
- c. Pseudomycelium of elongate cells, ogive cells in liquid wort.....*H. lambica*

#### KEY FOR THE SPECIES OF THE GENUS ZYGOMYCELOPSIS LODDER

- Spores Saturn-shaped, fermentation of glucose only.....*Z. californica*

## DISCUSSION

The results of this investigation have shown that the species *H. saturnus*, *H. suaveolens*, *H. Ciferri*, *H. Schneggii* and *H. lambica* are sufficiently distinct to be retained. The species *H. anomala*, *H. anomala* var. *sphaerica* and *H. anomala* var. *longa* have also been retained but redefined on the basis of cell size in liquid synthetic medium.

The characteristics of the species *H. nivea*, *H. panis*, *H. anomala* var. *robusta*, *H. anomala* var. *productiva* and *H. javanica* are not sufficiently distinct from the above three species to continue their separation as species or varieties.

Two cultures were sufficiently distinct from the described cultures to justify the establishment of a new variety, *H. anomala* var. *heteromorpha*, due to their formation of a pseudomycelia of heteromorphic cells in synthetic medium. Twelve cultures on the basis of their very poor film formation and poor growth in synthetic medium justified the establishment of a new species, *H. subpelliculosa*.

The morphological studies of the strains of *Hansenula* showed that, with the exception of cell size, there is very little difference between the films, slant cultures, giant colonies, spore formation and pseudomycelia. *H. saturnus* is readily distinguished from the other species by its Saturn-shaped spores.

Cell size in synthetic medium was used, in preference to liquid wort, as this medium can be easily duplicated and therefore the differences that occur in wort and other natural media used by various investigators can be eliminated. *H. anomala* and its varieties can only be separated on the basis of their cell size. This is not entirely satisfactory as the cultures show considerable variability in their cell size in the same medium and in different media. For example, a number of cultures placed in *H. anomala* var. *sphaerica* on the basis of cell size in synthetic medium form elongate cells in liquid wort and occasionally in synthetic medium. However, until more detailed studies are made on this variability within the cultures it seems best for the present to separate *H. anomala* and its varieties on the basis of cell size in synthetic medium.

This variability was also observed in *H. Ciferrii*. Spherical, oval and elongate cells were observed initially but during successive transfers on liquid wort the culture lost its ability to form elongate cells. Later a six month old agar slant was examined and a few elongate cells were observed. On transferring this culture to liquid wort spherical and oval cells were observed in the film and elongate cells and pseudomycelia of very elongate cells were found in the liquid and sediment.

Spore formation was observed in most cultures. With the exception of *H. saturnus* the spores were hat-shaped. Spore formation was obtained most readily with carrot wedges. The number of spores per ascus was variable and not only varied between the strains but in the same strain on different media. In some cases, where sporulation could not be obtained initially it could be induced by repeated transfers in grape juice, liquid wort, prune or cherry juice before transferring to carrot wedges or gypsum blocks. However, a few of the cultures lost their ability to sporulate during the culture in the laboratory and although repeated attempts have been made no sporulation could again be obtained.

The physiological condition of the culture also appears to play an important part in sporulation as it did not occur regularly on the media used. For example, sporulation was obtained within six days on carrot wedges after transfer from an actively growing culture at one time and at another time no sporulation was obtained within six weeks.

The slant cultures, giant colonies and films of the various cultures show some differences but as a whole are not suitable for the separation of species.

The pseudomycelia of all species except *H. saturnus* and *H. suaveolens* developed as long chains of elongate cells. Occasionally pyriform, clavate and other shaped cells were present, as in *H. anomala* var. *heteromorpha* where pseudomycelia of heteromorphic cells developed in synthetic medium. Budding may occur from any cell in the chain with the formation of a subsidiary chain, however the intersection of the branches usually occurs at cell junctions. The cells in these chains are loosely

held together and can be easily separated. Blastospores are formed and are spherical and oval.

With the formation of pseudomycelium the species of *Hansenula* show a very close relationship to the genus *Candida* as with the lack of sporulation the cultures could readily be placed in the species *Candida pelliculosa* as defined by Diddens and Lodder. Diddens and Lodder (1940) were able to show a close relationship between *H. javanica* and *H. anomala* and *Candida pelliculosa*.

The studies on the fermentation of sugars showed some differences. *H. saturnus* and *H. suaveolens* do not ferment galactose and maltose. *H. Schneggii* does not ferment raffinose, ferments sucrose slowly and galactose very slightly. *H. anomala* and its varieties, *H. Ciferri* and *H. lambica*, ferment glucose, fructose, mannose, galactose, maltose, sucrose and raffinose (1/3). *H. subpelliculosa* does not ferment galactose. *Zyghansenula californica* ferments glucose, fructose and mannose only.

The studies on the utilization of carbon compounds show some differences. *H. saturnus* and *H. suaveolens* were unable to utilize arabinose, galactose, maltose, phloridzin, dextrin, erythritol or  $\alpha$  methyl glucoside. Culture 39 placed in *H. anomala*, cultures 8, 9, 10, 11, 55 and 58 in *H. subpelliculosa* did not utilize galactose and cultures 45, 48 and 50 in *H. anomala* var. *sphaerica* did not utilize  $\alpha$  methyl glucoside. Ethyl alcohol, glycerol, mannitol, erythritol, dextrin, amygdalin, salicin, esculin, ethyl acetate, sodium pyruvate and xylose as well as the compounds mentioned above were utilized by all the other cultures. Lactose, inulin, starch, dulcitol, inositol, glycogen, acetone, isoamyl alcohol and methyl alcohol were not utilized by any of the cultures.

Acetic, citric, fumaric, lactic, malic, malonic and succinic acids were utilized by most of the species when the concentrations were not too high, e.g. 0.3 per cent. *H. saturnus* did not utilize malonic acid, *H. suaveolens* malonic and citric acid, and *H. Ciferri* acetic, citric, fumaric, malic and malonic acids. Succinic and lactic acids were the most readily utilized and acetic acid the least readily utilized. Adipic, butyric, caproic, crotonic, formic, glycollic, itaconic dl mandelic, maleic, mucic, oxalic, propionic

and tartaric acids were not utilized. Butyric, crotonic, maleic, and oxalic acids were toxic in concentrations of 0.2 per cent.

The studies on the utilization of nitrogen compounds showed that, with the exception of succinimide and guanidine the species of *Hansenula* show very little difference in their utilization. Glycine, dl alanine,  $\beta$  alanine, dl valine, dl leucine, l leucine, dl serine, l aspartic acid, d glutamic acid, d arginine, cysteine, cystine, dl phenylalanine, l histidine, tyrosine, tryptophane, dl  $\alpha$  amino n valeric acid, dl norleucine, proline, glycyl-glycine, ethyl amine, n butyl amine, tyramine, urotropine, acetamide, succinimide, guanidine, urea, asparagin, allantoin, uric acid, uracil, betaine, peptone, yeast nucleic acid, ammonium sulfate, potassium nitrate and sodium nitrite were all utilized. Succinimide was not utilized by *H. saturnus*, *H. Schneggii*, *H. Ciferri* and *H. suaveolens*, cysteine by *H. Ciferri* and guanidine by *H. Schneggii*, two cultures placed in *H. anomala* and nine cultures placed in *H. anomala* var. *sphaerica*. Sarcosine was only utilized by *H. saturnus*. Only 33 per cent of histidine and 50 per cent tryptophane were utilized. Comparing these results with those obtained by Thorne (1933) and Nielsen (1936, 1938) we see that the species of *Hansenula* are able to utilize nitrogen compounds as cystine, acetamide, allantoin, betaine and  $\beta$  alanine which were not utilized by the strains of *Saccharomyces cerevisiae*. Many of the cultures were also able to utilize both forms of the racemic mixtures and d arginine completely whereas Nielsen found that, with the exception of aspartic acid, asparagin and glutamic acid, his culture was able to utilize only half of the racemic mixture and half of d arginine.

The nitrogen assimilation by *H. subpelliculosa* and *Zygo-hansenula californica* was only shown by the auxanogram method as these two species grow very poorly in synthetic medium. None of the species studied other than *Hansenula* assimilate nitrate or nitrite.

The occurrence of slight growth and a change in pH is not a true indication of the ability of the organism to utilize the compounds. This is shown, for example, with *H. saturnus* and *H. suaveolens* with maltose and galactose as carbon sources, where there was a slight amount of growth and a definite change in

pH but quantitative determinations show that these compounds are not utilized. Nielsen (1936) has shown that the yeast can increase its solid matter up to three times the original amount without any utilization of the nitrogen compound.

The morphological studies on the cultures included in the genus *Pichia* and *Candida Krusei* showed that they are similar to the species of *Hansenula* in cell size, film formation, slant cultures, giant colonies and pseudomycelium formation. All strains of *Pichia* formed hat-shaped spores with a narrow brim. The physiological studies showed considerable differences: *Pichia fermentans* and variety *rugosa*, *Pichia Kluyveri* and *Candida Krusei* fermented glucose, fructose and mannose only. Only ethyl acetate and xylose were utilized. With the exception of *Pichia Kluyveri* they all utilized the organic acids except malonic acid as the species of *Hansenula*. *Pichia Kluyveri* and *Candida Krusei* formed ester.

#### SUMMARY

A morphologic and taxonomic study has been made of 100 cultures of yeast obtained as species of *Hansenula* from various sources in the United States, Europe, Asia and South Africa. This collection yielded 79 cultures of *Hansenula*, 6 of *Pichia*, 8 of *Candida*, 2 of *Torulopsis*, 2 of *Zygothansenula* and 1 of *Brettanomyces*. The cultures of *Hansenula* were placed into seven species and three varieties. They are *H. saturnus*, *H. suaveolens*, *H. Schneggenii*, *H. lambica*, *H. Ciferri*, *H. anomala* and the varieties *H. anomala* var. *sphaerica*, *H. anomala* var. *longa* and *H. anomala* var. *heteromorpha*, and *H. subpelliculosa*. The species are differentiated by their fermentation, film, cell size, pseudomycelium formation and growth in synthetic medium. The varieties are differentiated by cell size in synthetic medium and pseudomycelium formation.

The cultures of *Pichia* studies were placed in the species *Pichia Chodatii*, *P. fermentans*, *P. fermentans* var. *rugosa* and *P. Kluyveri*. The other organisms identified were *Candida Krusei*, *C. Guilliermondii*, *Brettanomyces bruxellensis*, *Torulopsis californicus* and *Zygothansenula californica*.

The observations made concerning variation, particularly in the species *H. anomala* and its varieties, indicate that a study

of the homozygous or heterozygous nature of single cells will be necessary before the limitation of species or varieties can be definitely established.

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UNIV. OF CALIFORNIA,  
BERKELEY, CALIF.

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# SOME ADDITIONAL SPECIES OF CERATOSTOMELLA IN THE UNITED STATES

ROSS W. DAVIDSON<sup>1</sup>

(WITH 4 FIGURES)

## INTRODUCTION

In North America considerable attention has been given to the species of the genus *Ceratostomella* that stain wood (4, 10, 17, 20, and 23) and that cause plant diseases (1, 2, 3, 11, and 14). Such studies indicate the economic importance of the genus, but the present paper deals with a number of species that have been isolated from wood in the course of decay studies and so far as is known were not associated with pronounced discoloration or disease in the host substrata. The five species described here fall into two fairly distinct groups, which have been referred by some mycologists to separate genera. For the present they are being assigned to the genus *Ceratostomella* with an indication of the subgroup to which they belong.

## DESCRIPTION OF THE SPECIES

### 1. *Ceratostomella* (*Ophiostoma*) *microspora* sp. nov. (FIG. 1, H-K; FIG. 2, G-I)

Mycelium growing slowly in culture, remaining white; perithecia begin to form in about two weeks, maturing slowly, black-nearly spherical, 200–270  $\mu$  in diameter, thick walled; beaks occasionally two on a perithecium, 1.2–1.6 mm. long by 60–75  $\mu$  thick at base to 18–19  $\mu$  thick just below ostiole; no filaments around the ostiole, but in very mature condition hyphae spread slightly to form a funnel-like opening; asci elongate ovoid, small evanescent; ascospores not collecting in a globule at the ostiole but running down on the outside of the beak, light pinkish-brown in mass, hyaline under the microscope, minute, 1.5–2.5  $\times$  0.5  $\mu$

<sup>1</sup> Latin descriptions of the new species included in this paper were prepared by Edith K. Cash, assistant mycologist, Bureau of Plant Industry, United States Department of Agriculture.

conidia borne singly on hyphae or around the apex of hyaline cephalosporium-like conidiophores, usually slightly curved,  $4-10 \times 1.2-2 \mu$ , hyaline. Growth rate: 5 mm. in 5 days.<sup>2</sup>

Mycelio in culturis lente crescenti, albo; peritheciis atris, sphericis,  $200-270 \mu$  diam., 1-2-rostratis; rostris longis,  $1.2-1.6$  mm., basi  $60-75 \mu$ , apice  $18-19 \mu$  crassis; ciliis ostiolaribus nullis; ascosporis parvis, hyalinis,  $1.5-2.5 \times 0.5 \mu$ ; conidiis hyalinis, elongatis, curvulis,  $4-10 \times 1.2-2 \mu$ .

Isolated from a chestnut stump, State College, Pennsylvania, October 8, 1932, and from the heartwood of *Quercus* sp. near Edinburg, Virginia, 1934.

This fungus differs from most of the others in the absence of well-defined bristles or cilia around the ostiole (FIG. 1, I). The perithecia develop very slowly and the beaks increase in length even after the ascospores are being ejected in abundance. The beaks always seem to grow toward the light. Cultures with the necks all growing in the direction of a window on one side of the laboratory have been turned in the opposite direction and on increased growth they curved back toward the window again.

A dense white growth of aerial mycelium and conidiophores covers the surface of the substratum and usually persists even after the perithecia are mature. The mycelium of the substratum also remains hyaline (FIG. 2, G-I), except for the dark-brown hyphae covering the perithecia.

The absence of bristles around the ostiole and the fact that no *Graphium* stage is produced by cultures of this species separates it from *C. Querci* Georgevitch (5), *C. merolinensis* Georgevitch (6), and *C. Fagi* Loose (13). At first it was thought that it might be similar to *C. mycophila* Rick (18), which grows on *Polyporus* sp., but examination of a specimen collected by Rick disclosed that species to have persistent asci and light-brown allantoid *Valsa*-like ascospores.

## 2. CERATOSTOMELLA (OPHIOSTOMA) STENOCERAS Robak? (FIG. 1, A-C; FIG. 2, C-E)

Mycelium growing slowly in culture, becoming dark brown, developing dark segments or remaining white; perithecia begin to form in 2 to 3 weeks and mature slowly, usually very numerous

<sup>2</sup> Throughout this study growth rate is recorded as average radial growth of mycelium on 2.5 per cent malt agar at room temperature of about 25° C.

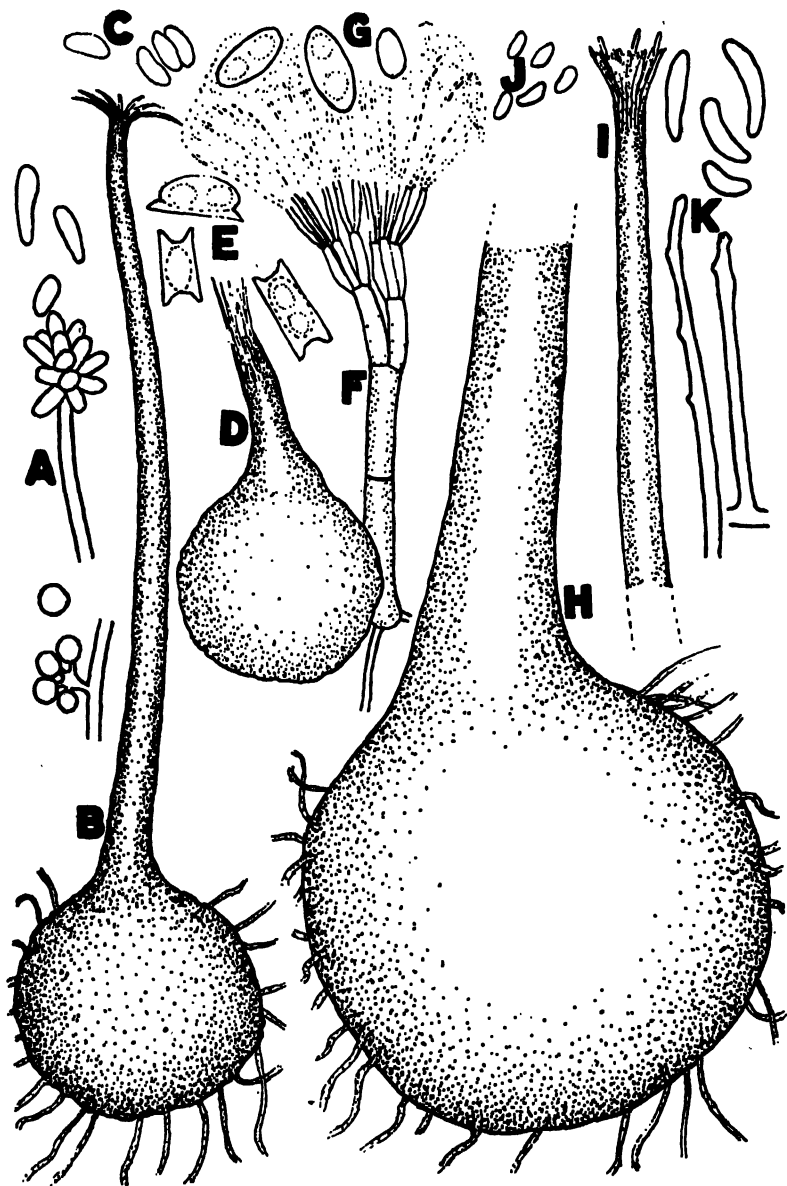


FIG. 1. A-C, *Ceratostomella stenoceras* Robak ?—A, conidia and conidiophores,  $\times 1500$ ; B, perithecium,  $\times 240$ ; C, ascospores,  $\times 1500$ . D-G, *Ceratostomella leptographioides*—D, perithecium,  $\times 240$ ; E, ascospores,  $\times 2000$ ; F, conidiophore,  $\times 600$ ; G, conidia,  $\times 2000$ . H-K, *Ceratostomella microspora*—H, perithecium,  $\times 240$ ; I, tip of perithecial beak,  $\times 240$ ; J, ascospores,  $\times 1500$ ; K, conidia and conidiophores,  $\times 1500$ .

black, spherical, 95–140  $\mu$  in diameter; beaks smooth, black, 370–650  $\mu$  long by 25  $\mu$  thick at base to 13  $\mu$  thick at ostiole; ostiole surrounded by a fringe of hyaline, slender, flexuous, filaments, 30–40  $\times$  1.2  $\mu$ ; asci small, globular, soon disappearing; ascospores hyaline, collecting at the ostiole in a hyaline spherical mass, 4–4.8  $\times$  1.5–1.8  $\mu$ ; conidia borne at the apex of hyaline conidiophores in cephalosporium-like heads, elongate or nearly spherical, hyaline, one-celled, 4–8  $\times$  1.4–2  $\mu$  or 2.8–5  $\mu$  diameter. Growth rate 5½ mm. in 5 days.

Isolated from heartwood of living *Quercus* sp. decayed by *Stereum frustulosum* Fries, Hyde Park, N. Y., December 1933; from heartwood adjacent to 1-year-old injuries in trunks of *Quercus* sp. at Mt. Solon, Va., 1934; from *Quercus* sp., Edinburg, Va., and Southern, N. J., 1935; and from *Betula populifolia*, Morristown, N. J., 1935; and others.

Typical cultures of this species on 2½ per cent malt agar develop only a sparse growth of aerial mycelium and conidiophores which disappear as the cultures become darker and begin to develop perithecia. Other strains of the same or a closely related species do develop a heavier more persistent growth of conidiophore bearing mycelium (FIG. 2, E) and do not darken up as much as some of the so-called typical culture (FIG. 2, C). On Difco potato dextrose agar with .5 per cent malt added all cultures develop a heavier growth of aerial mycelium. Cultures held for several years and retransferred occasionally have lost all or some of the dark color (FIG. 2, D), but even entirely white cultures may develop some normal perithecia.

The perithecia of *C. stenoceras* develop slowly and sparsely on young cultures. They begin to form in 2 to 3 weeks and mature slowly, but (on recently isolated cultures especially) they continue to develop and in 4 to 6 weeks are present in great abundance. In this slow growth of mycelium and development of the perithecia it differs from many of the blue-staining species, such as *C. pilifera* (Fries) Wint., *C. pluriannulata* Hedgc. (FIG. 2, F), and the lumber-inhabiting species *C. multiannulata* Hedgc. & Davidson (4), but is similar in this respect to *C. microspora*.

The cultures obtained in this country are similar in some respects to *C. stenoceras* Robak (19), but the perithecia are smaller and develop more slowly. The ostiolar beaks are shorter on the

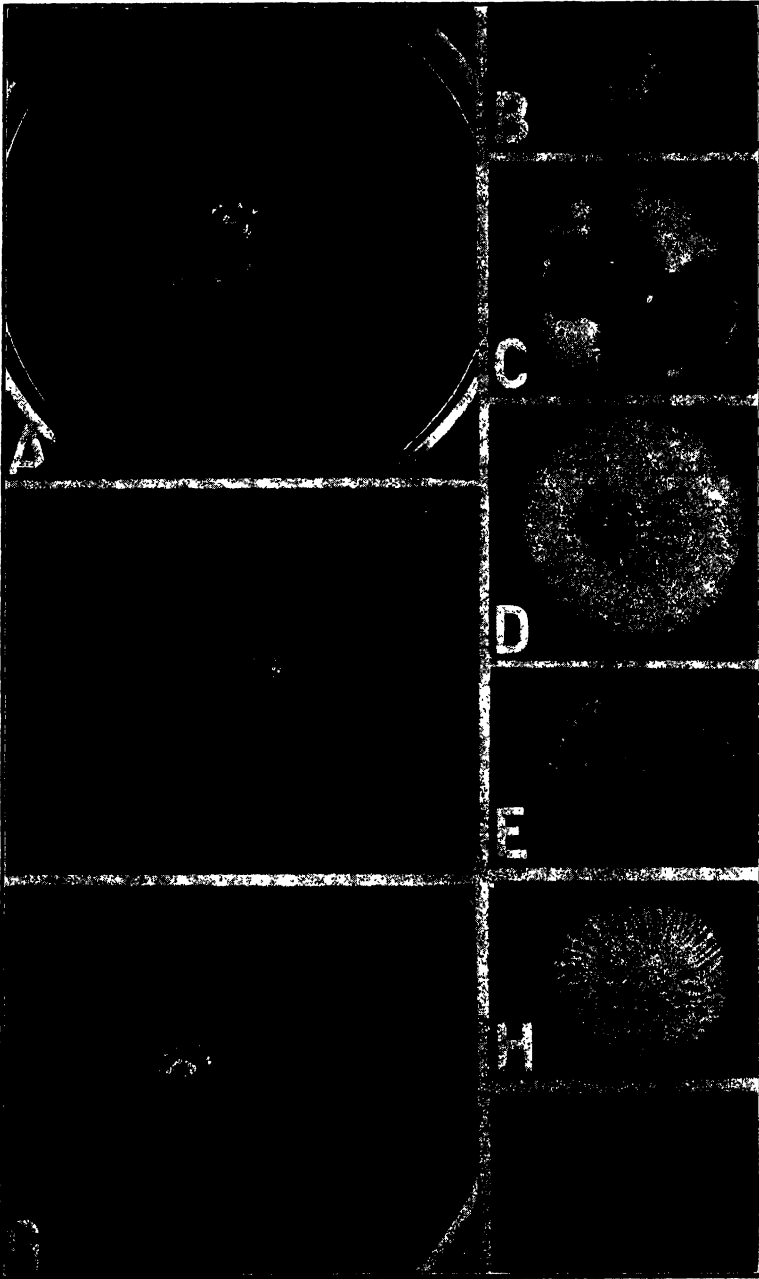


FIG. 2.

average than those described for *C. stenoceras*. On malt agar the growth is sometimes similar to zoned cultures described by Robak for his fungus, but usually the zonation is not pronounced. It differs from *C. Castaneae* Vanin & Solovjev (22) in its larger perithecia and shorter beaks. Also, ostiolar cilia of *C. Castaneae* are given as 14.7–20  $\mu$  long while those of our fungus are 30–40  $\mu$  long. *C. Querci* Georgevitch (5), *C. merolinensis* Georgevitch (6), and *C. Fagi* Loose (13) all have larger and longer beaked perithecia. They are also described as having *Graphium* imperfect stages whereas *C. stenoceras* has no such stage.

This is the most common *Ceratostomella* isolated from hardwoods, especially heartwood of *Quercus* sp. Many cultures of it have been studied and considerable variation observed, but for the present they are all being referred to *C. stenoceras* Robak.

### 3. CERATOSTOMELLA (OPHIOSTOMA) MINUTUM Siem. (FIG. 3, F–H; FIG. 4, A–C)

Mycelium remaining white, growing slowly; perithecia begin to form in 2 to 3 weeks and mature slowly, scattered, small, black, spherical, 60 to 80  $\mu$  diameter, rough; beaks of perithecia also rough, black, thick, cylindrical or tapering, short, 45 to 90  $\mu$ , sometimes longer; bristle-like cilia forming a tepee-shaped cone over the ostiole, light brown, pointed, about  $12 \times 1\text{--}1.2 \mu$ , and 8 to 12 in number; asci evanescent, not seen, but ascospores are arranged in groups of 8 within the perithecium; ascospores long, slender, slightly curved, pointed at the ends, about 10–15  $\mu$  long by 1  $\mu$  wide, hyaline, 1-celled; conidia borne at apex of hyaline cephalosporium-like conidiophores in globular bunches, 4–8  $\times$  2–4  $\mu$ , hyaline, 1-celled; growth rate, 4 mm. in 5 days.

Isolated along with a fast-growing species of *Cephalosporium* and a *Bacterium* from slightly stained sapwood of a dead pine trunk infested with *Monochamus titillator* Fabr. and several species of nematodes, collected near the District of Columbia,

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FIG. 2. A, 10-day-old culture of *Ceratostomella leptographioides*; B, 10-day-old culture of *Ceratostomella rostricylindrica*; C–E, 10-day-old cultures of *Ceratostomella stenoceras* Robak?—C, dark culture; D, white culture; E, culture with abundant aerial growth; F, 10-day-old culture of *Ceratostomella pluriannulata* Hedge.; G, 35-day-old (perithecia developed), and H and I, 10-day-old (perithecia not yet developed) cultures of *Ceratostomella microspora*; all  $\times 1$ . (Photographs by M. L. F. Foubert.)

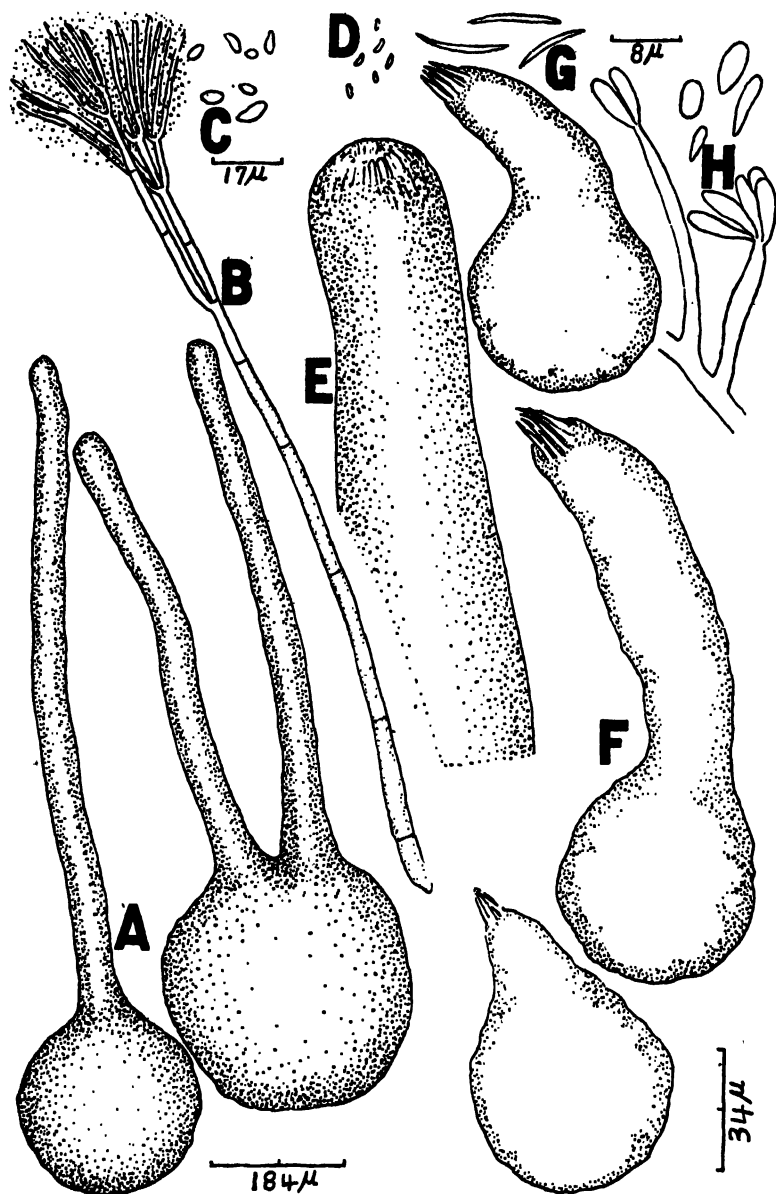


FIG. 3. A-E, *Ceratostomella rostrocylicindrica*—A, perithecia; B, conidiophore; C, conidia; D, ascospore; E, tip of perithecial beak. F-H, *Ceratostomella minutum* Siem.—F, three perithecia; G, ascospores; H, conidia and conidiophores.

August 1934. It was also isolated from several of the *M. titillator* grubs that had been surface-sterilized.

*Ceratostomella minutum* differs strikingly from any other species known to the writer. The short thick perithecial necks topped by the compact conically arranged bristles (FIG. 3, *F*; FIG. 4, *A* & *B*) and the long narrow ascospores (FIG. 3, *G*) are outstanding features that separate it from other species. The American fungus is here considered the same as Siemaszko's (21) species although the perithecia studied by the writer are smaller. The American fungus was studied only in cultures on malt agar, as developed in association with the *Bacterium* (FIG. 4, *C*). Single-spore cultures did not develop perithecia.

4. *Ceratostomella* (*Grosmannia*) *leptographioides* sp. nov. (FIG. 1, *D-G*; FIG. 2, *A*)

Mycelium light-gray in culture, soon covered with conidiophores; perithecia forming in 4 or 5 days, maturing slowly, abundant, black, spherical, 100–150  $\mu$  in diameter; beaks short, 150–180  $\mu$  long by 35–40  $\mu$  thick at base to 20  $\mu$  at ostiole; cilia numerous, straight, bristle-like, hyaline, pointed at ends, 16–28  $\mu$  long; asci small, disappearing; ascospores hyaline, kidney-shaped surrounded by a gelatinous sheath, 6–7.5  $\times$  2.8–3.8  $\mu$  including sheath; conidiophores as in *Leptographium*, brown, septate, with hyaline brush-like branches at apex, 150–250  $\mu$  high by 4–7.5  $\mu$  thick; conidia borne at tips of hyaline branches, small, hyaline, 2–7  $\times$  1.5–3.5  $\mu$ . Growth rate 13 mm. in 5 days.

Mycelio moderatim crescenti, griseo; peritheciis abundantibus, parvis, atris, sphericis, 100–150  $\mu$  diam.; rostris brevibus, atris, 150–180  $\mu$  longis, basi 35–40, apice 20  $\mu$  crassis; ciliis setiformibus, hyalinis, acuminatis, 16–28  $\mu$  longis; ascosporis reniformibus, hyalinis, in vagina gelatinosa vestitis, 6–7.5  $\times$  2.8–3.8  $\mu$ , vagina inclusa; conidiophoris ut in *Leptographio*, brunneis, septatis, apice multo ramosis, 150–250  $\mu$  altis, 4–7.5  $\mu$  crassis; conidiis parvis, hyalinis, 2–7  $\times$  1.5–3.5  $\mu$ .

Isolated from heartwood of stump of *Quercus* sp., Edinburg, Va., February 1934, and from specimen of decayed *Quercus* sp. stump from Ohio, 1936.

Two other species of this group are *C. penicillata* Grosmann (9) and *C. piceaperda* Rumbold (20), which have much larger and longer beaked perithecia and are faster growing. Goidanich (7) set up the genus *Grosmannia* for species of *Ceratostomella* having *Leptographium* conidial stages. He also described *G.*



*serpens* Goid., which is more closely related to *C. penicillata* and *C. piceaperda* than to this or the following species.

5. *Ceratostomella* (*Grosmannia*) *rostracylindrica* sp. nov. (FIG. 2, B; FIG. 3, A-E)

Mycelium growing very slowly in culture, white or gray at first, finally becoming dark brownish gray, surface slimy, appressed, with very sparse aerial conidiophores and mycelium; perithecia develop slowly, maturing in 4 to 6 weeks, black, large, about 300  $\mu$  in diameter; beaks 400–600  $\mu$  long, black, sometimes 2 or 3 to a perithecium, cylindrical, and with no fringe of cilia around ostiole; ascospores small, 2–4  $\times$  1–1.6  $\mu$ , hyaline; conidiophores as in *Leptographium*, single or grouped, brown, septate, relatively small, 100–350  $\mu$   $\times$  2.5–5  $\mu$ ; conidia on penicillate branches at apex of conidiophores, globose or elongate, 2–6  $\times$  1–3.5  $\mu$ . Growth rate 2–3 mm. in 5 days.

Mycelio in culturis lentissime crescenti, griseo; peritheciis tarde maturantibus, stris, magnis, 300  $\mu$  diam.; rostris interdum 2–3, longis, cylindricis, atris, 400–600  $\mu$  longis, ciliis nullis; ascosporis parvis, hyalinis, 2–4  $\times$  1–1.6  $\mu$ ; conidiophoris ut in *Leptographio*, brunneis, septatis, apice multo ramosis, 100–350  $\times$  2.5–5  $\mu$ ; conidiis hyalinis, parvis, 2–6  $\times$  1–3.5  $\mu$ .

Isolated from heartwood of *Quercus* sp. from Connecticut, September 1936.

Growth is much slower than that of any other species of the group (FIG. 2, B). Conidiophores are smaller and less abundant than for any described species of *Leptographium*. This and the preceding species grow more slowly and differ from the non-perithecial species *Leptographium Lundbergii* Lagerberg & Melin (12) in general growth characteristics. A number of forms having no perithecial stage have been isolated from pine wood in this country, but in general most of them fit the description of *L. Lundbergii* fairly well, except for their longer conidiophores, and are more nearly similar to conidial stages of *Ceratostomella penicillata* and *C. piceaperda* than to either of the two species of the group described here.

#### DISCUSSION

##### *Single-spore Cultures*

The writer has not made a study of single-ascospore cultures of the new species described in this paper, but a few single conidial

cultures were obtained. Single conidial cultures of *C. stenoceras* did not develop in an entirely normal manner, but some mature ascospore-bearing perithecia developed in five of eight such cultures. The other three cultures contained only immature perithecia. None of these cultures developed the black crustose

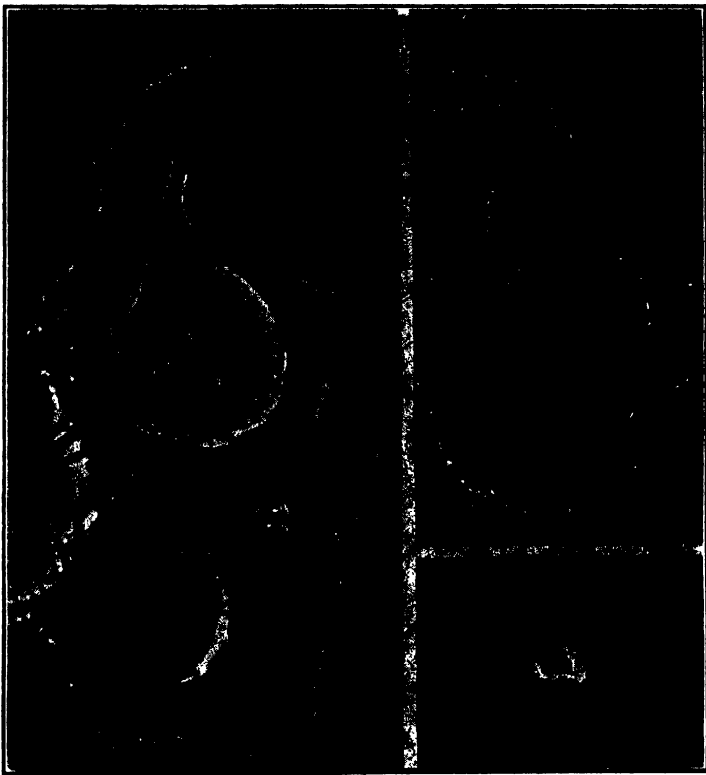


FIG. 4. *Ceratostomella minutum* Siem. A and B, photomicrographs of sections through mature perithecia,  $\times 600$ ; C, 10-day-old culture with bacterial contaminant,  $\times 1$ . (Imbedding and sectioning by Dorothy Blaisdell Vaughn. Photomicrographs and photograph by M. L. F. Foubert.)

concentric zones that were frequently formed by the original isolations. The mass isolates of *C. stenoceras* sometimes do not develop perithecia very readily on malt agar, so the fact that three of the single conidial cultures did not have mature perithecia does not prove that they were incapable of producing fertile perithecia.

All of the single conidial cultures of *C. microspora* obtained developed mature perithecia, as did those of *C. leptographioides*.

### *Taxonomic Considerations*

Melin and Nannfeldt (15) have pointed out the differences between species originally described in the genus *Ceratostomella* and the numerous species later described as having ephemeral asci and also placed in the same genus. The writer agrees that the species that Nannfeldt and Melin place in *Ophiostoma* are probably generically distinct from *Ceratostomella vestita* Sacc. and related species, but can not agree with his statement that *C. penicillata* "can not be included in it (*Ophiostoma*), as it lacks the fringe of ostiolar cilia." If the ostiolar cilia are to be considered such an important character, *C. leptographioides* would have to be placed in a separate genus from *C. penicillata* along with species more distantly related.

It is the writer's opinion from a study of a considerable number of species, some of which belong in every known group of the genus *Ceratostomella* (except the *C. vestita* and *C. cirrhosa* group), that neither the ostiolar filaments nor any other perithecial character can be used in separating the groups of the genus.

Our present knowledge of this *Ceratostomella* complex indicates that conidial stages are much more reliable for placing the species in their natural groups. The endoconidial group has already been separated by the writer (4) and placed in the genus established by Münch (16), and no doubt the *Leptographium* forms should also constitute a separate genus, as was concluded by Goidanich (8). The remaining species should be more clearly defined by further investigations, but probably will be considered a heterogeneous mixture of closely related groups and placed in the genus *Ophiostoma*. It might be pointed out, however, that whereas many species of the *Ophiostoma*, *Grosmannia*, and *Endoconidiophora* groups have been carefully studied in pure culture, none of the species of *Ceratostomella* having persistent asci has, so far as the writer is aware, been studied in culture. Therefore, it is possible that there may not be distinct cultural differences between them. A study of *C. vestita* and related species with

persistent asci seems necessary for a better understanding of their relationship to the other groups of species.

DIVISION OF FOREST PATHOLOGY,  
BUREAU OF PLANT INDUSTRY,  
UNITED STATES DEPARTMENT OF AGRICULTURE,  
WASHINGTON, D. C.

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# SOME NEW AND INTERESTING FUNGI FROM MOUNT SHASTA

LEE BONAR AND WM. BRIDGE COOKE

During the past few summers several interesting species of fungi have been collected by the junior author on Mount Shasta, situated in south central Siskiyou County in northern California. Studies made on some of these fungi have found them to be heretofore unreported, others are new to North American records. Many of the microscopical observations to be reported were made by the senior author.

## PLEOSPORA AND LEPTOSPHAERIA

A number of collections of species in these two genera have been made. They occur on dead fragments of herbaceous plants. Above-ground portions of perennial herbs, both monocots and dicots, are subject to rapid decay. This takes place during two successive winters. During the first winter after the plant has bloomed and fruited the plant is covered with snow. After the snow has melted, species of these two genera, as well as species of other Ascomycetes, are found on stems of any species observed. During the second winter decay is completed since no remains are found at its close. So far as collections made to date show species of *Leptosphaeria* predominate on monocot hosts while species of *Pleospora* predominate on dicots.

On overwintered parts of various grasses, sedges and rushes have been found material of what might be referred to three species of *Leptosphaeria*. Karsten described three species of *Leptosphaeria* from similar hosts on Spitzbergen: *L. vagans* on grasses, *L. caricinella* on sedges and *L. junciseda* on rushes. Our material corresponds with these three species. However, on closer examination the three species appear to be identical, both from the Saccardian translation of the type description and from the material at hand. This also indicates that too close a dependence on the host cannot indicate lines between species in

this genus. Comparative tables listing species of this genus found on Gramineae, Cyperaceae and Juncaceae also indicate a lack of specific differentiation in this group based on the host relationship.

Comparative lists of all species of *Pleospora* listed in Saccardo indicate that specific differences in this genus are based in many cases on host relationships which, in the case of fungi growing on dead herbaceous matter, appear to be of little importance. From a wide range of hosts, specimens of *Pleospora permunda* (Cooke) Sacc. have been obtained. Should the common practice of including minor variations of spore size on different hosts be followed here, a number of species or varieties could be erected. At present it appears, however, that fewer species, rather than more, should be the rule in this and related genera. *Pleospora* is a genus which was based, among other morphological characters, on its muriform spores. It was segregated into *Clathrospora* on the basis of the spores in certain species being septate in only two dimensions, spores which appear like those of *Pleospora* in one plane and like those of *Leptosphaeria* in the other, producing flattened spores. It was further segregated into *Catherinia* on the basis of certain species which possessed hyaline spores. We have not found species of *Catherinia* on Mount Shasta, but because certain *Catheriniae* possess dilute chlorinous to even pale yellow spores, and some *Pleosporae* possess spores as pale as chlorinous it is suspected that there is no generic difference here. The difference between muriformness of a two- or three-dimensional quality appears to be negligible when segregating portions of *Pleospora*; thus *Clathrospora*, in which *P. permunda* was described by M. C. Cooke, appears to be a superfluous genus. Most *Pleospora* species with 3, 4, 5, 6 and 7 longitudinal septae appear to be reported as septate in only two dimensions.

#### SPECIES IN OTHER GENERA

##### METASPHAERIA SEPALORUM Vleugel.

Perithecia crowded in black tuberculate masses, becoming superficial, globoid, nested in a cottony black subiculum and only barely visible, not stromatic; walls hairy, thin, flexuous, black, tending to separate when masses are crushed; ostiole poroid, not papillate; perithecia 290–325  $\mu$  in diameter, subepidermal in

origin; asci 8-spored,  $96-120 \times 15-19 \mu$ ; paraphyses flexuous, simple to anastomosed and branching; spores 3-septate, with hyaline walls and light brown contents, appearing completely hyaline in phloxine,  $30-33 \times 7-9.5 \mu$  (LB),  $26.2-30.5 \times 7-9.5 \mu$  (WBC).

On perianth segments of *Juncus Parryi* Engelm. in the summer of the year following the blooming period. WBC 10303, Mount Shasta, The South Gate, 8000 feet.

***Bifusella acuminata*** (Ellis & Ev.) Bonar & W. B. Cooke, comb. nov. (*Duplicaria acuminata* Ellis & Ev. Proc. Acad. Phil. 1895: 429.)

Hysterothecia subcuticular in origin, sessile, black, shining, smooth, rectangular with rounded corners, 0.75–1 mm. long, opening not evident in most, a mere slit in one or two; wall carbonized,  $25 \mu$  thick above, thinner below, no distinct labia; asci 8-spored,  $115-130 \times 18-20 \mu$ ; paraphyses few, simple contorted or spiraled above, not always the full length of the asci; spores hyaline,  $28-33 \times 3.5-4 \mu$ , not including the sheath (soluble in KOH) which is as thick as the dumbbell-shaped spore and hyaline.

On *Juncus Parryi* Engelm. culms. WBC 10184, near Horse Camp, Mt. Shasta, 8000 ft., and WBC 10303 in the South Gate, Mt. Shasta, 8000 ft.

***Lophodermium Phloxii*** Bonar & W. B. Cooke, sp. nov.

Hysterotheciis epiphyllis, nigris, subepidermalibus, acutis fuseoideo-ellipticus, 0.75–1.25 mm.  $\times$  500–600  $\mu$ ; labiis carbonaceis, agglutinatis epidermide; periphysibus obscure; ascis 8-sporis, clavatis, apice subacutis, basi brevistipitatis,  $120-130 \times 12-14.5 \mu$ ; paraphysibus filiformibus, apice vix inflatis, simplicibus, 3–4  $\mu$ , plus minusve conglutinatis et epithecium formantibus; sporidiis fasciculatis, filiformibus, unicellularibus, subhyalinis, 55–70  $\times$  1.5–2.5  $\mu$ , in muco immersis.

Hysterothecia on leaves, black, shining, acute fusoid-elliptic, 0.75–1.25 mm.  $\times$  500–600  $\mu$ ; subepidermal in origin; labia heavily carbonized with involved epidermis, 130  $\mu$  thick; periphyses gelatinized and indistinct; basal layer parenchymatic, carbonized, 25–30  $\mu$  thick, this overlaid by conspicuous, subhyaline, subhymenium; asci clavate, symmetrical, subacute at tip, tapers toward short stalk,  $120-130 \times 12-14.5 \mu$ , 8-spored, spores straight in ascus; paraphyses simple, flexuous, enlarged at tip to 3–4  $\mu$ , somewhat gelatinized and forming an epithecium; ascospores



straight, filiform, slightly enlarged above, 1-celled, subhyaline,  $55-70 \times 1.5-2.5 \mu$ , encased in thin hyaline gelatinous sheath.

On *Phlox Douglasii* Hook. WBC 10185, on moist flat at Horse Camp, Mt. Shasta, 8000 ft. Possibly this fungus is associated with *Macrophoma cylindrospora* previously reported from the same colony of host plants but not found in 1938 when this collection was made.

**Phyllosticta Fritillariae** Bonar & W. B. Cooke, sp. nov.

Pycnidia dense gregariis, nigris, contextu laxiuscule cellulose,  $90-125 \mu$  in diam., sporulis bacillaribus,  $1.5-1.9 \times 2.3-2.5 \mu$ ; ostiolo obscuro.

Pycnidia thick-walled, densely gregarious, black, covering entire plant and blackening it on both sides of leaves as well as on stems and petioles; tissues of plant filled with brown hyphae with cells  $10-20 \times 3.5-4 \mu$ ; cells of outer layers of pycnidia obovate to ovate,  $6-8 \times 4 \mu$ ; pycnidia  $90-125 \mu$  in diam.; spores bacillar,  $1.5-1.9 \times 2.3-2.5 \mu$ ; ostiole present but indistinct.

On *Fritillaria atropurpurea* Nutt. WBC 15583, Wagon Camp, Mt. Shasta, 5700 ft. Two plants in a large colony of the host were infected. Infection resulted in dwarfing of the infected plants. In early stages the fungus appears as pale brown spots on straw colored leaves. No spores are associated with this phase.

There appear to be no described species of *Phyllosticta* on *Fritillaria*. Our fungus shows characters close to those of *P. hispida* Ellis & Dearness on *Smilax* in Eastern Canada. The symptoms of the latter fungus on parts of *Smilax* leaves would apply to those on our whole plant. Because of the nature of the present species concept in the form genus *Phyllosticta* it seems best, because of the geographic and host discontinuity of these two fungi, to retain them as separate species until further studies prove otherwise.

**PHYLLOSTICTA MONARDELLAE** W. B. Cooke in Mycobiota of North America 70.

Spots without definite margins, finally covering the entire leaf; leaf becoming brown; pycnidia black-punctate, separate, rarely 2-3 together, not confluent, spherical, not flattened by mutual pressure, hypophyllous, black,  $60-120 \mu$  in diameter; spores hyaline, rod-shaped,  $1-1.5 \times 4-5 \mu$ .

On *Monardella odoratissima* Benth. WBC 13404, near Wagon Camp, Mt. Shasta, 6000 ft. There appear to be no hitherto reported species of *Phyllosticta* growing on species of *Monardella*.

***Phyllosticta nigrescens* Bonar & W. B. Cooke, sp. nov.**

Maculis ochraceis, margine olivaceis, extendentibus ad omne folium, denique nigrescentibus; pycnidiis sparsis, punctiformibus, epiphyllis, membranaceis, 100–130  $\mu$  diam.; ostiolo poroso; sporulis hyalinis, bacilliformibus, 5–6  $\times$  1.5–2  $\mu$ .

Spots light tan, with olivaceous margin, spreading from tip or margin to involve entire leaf, finally becoming black; pycnidia scattered, single, epiphyllous, not visible below; thin-walled, 100–130  $\mu$  in diam.; ostiole poroid or slightly papillate; spores 1-celled, hyaline, bacilliform, 5–6  $\times$  1.5–2  $\mu$ .

On *Viola purpurea* Kellogg. WBC 13403, above Wagon Camp, Mt. Shasta, 6000 ft. On *Viola Sheltonii* Torr., collected by J. P. Tracy on Grouse Mountain, Humboldt Co., Calif.

***Septoria shastensis* Bonar & W. B. Cooke, sp. nov.**

Maculis ochraceis, demum bruneis et extendentibus ad omne folium, pycnidiis sparsis, globosis, membranaceis, 100–150  $\mu$ , ostiolo epiphyllis; sporulis saepe paulum curvatis, plerumque sinuatis, 1–3-septatis, subhyalinis ad dilute brunneis, 20–38  $\times$  2.8–3.8  $\mu$ .

Pycnidia evenly scattered in leaf; leaf finally turns brown from tip or margin to involve entire leaf; pycnidia globoid, 100–150  $\mu$ , wall distinct all around but membranous, showing on both surfaces but openings epiphyllous; spores usually somewhat curved, mostly sinuous, 1–3-septate, dilute brown or subhyaline, 20–38  $\times$  2.8–3.8  $\mu$ ; spore tips blunt rather than acicular.

On *Aster shastensis* Gray. WBC 15601, in chaparral along the Memorial Highway, Mt. Shasta, 4500 ft.

Several species of *Septoria* have been recorded on *Aster* spp. Of these *Septoria tharpiana* Trott. (*S. angularis* Tharp) appeared to be most closely related. However, on examination of type material of this species, kindly loaned by J. A. Stevenson, Mycological Collections, Bureau of Plant Industry, *S. tharpiana* was found to be quite different from the Mount Shasta material. *S. tharpiana* has longer, more slender spores and pycnidia in definite angular spots. *S. astericola* Ellis & Ev. has rounded or ovate rather than angular spots, while *S. atropurpurea* Peck has definitely purple spots. Again in these species the spores are different.

OLLULA PEZIZOIDEA Lév. Ann. Sci. Nat. IV 20: 299. 1863.

(*Siroscyphellina Arundinaceae* Petrak, Ann. Myc. 21: 255. 1923.)

Fruiting bodies 2-6, reddish flesh-colored, crowded erumpent in old leaf scars; shape irregular from crowded position or flattened globoid, up to 1 mm. in diameter; with a wide opening at top; fruiting bodies separate, not on a stroma common to clusters; conidiophores crowded around the walls of the fruiting body, branched, hyaline; conidia  $3-5 \times 1-1.5 \mu$ , hyaline, 1-celled.

On a twig of *Abies magnifica* var. *shastensis* Lemmon. WBC 15726. Near Horse Camp, Mt. Shasta, 8000 ft.

The material agrees with the descriptions of this species except that it is erumpent rather than superficial and that each fruiting body has its own pseudoparenchymatic stromatic base rather than such a base being common to several fruiting bodies.

RAMULARIA OBDUCENS Thuem.

Material referred to this species was collected on a colony of *Pedicularis densiflora* Benth. (WBC 15502, June 1941). The colony of the host which was growing along a roadside on the outskirts of Mount Shasta City, formerly Sisson, was heavily infected. The only previous report of a species of *Ramularia* parasitizing a species of *Pedicularis* in the United States was that of a collection made in 1925 at approximately the same location—Sisson, California.

Material of these species is deposited in the herbarium of the University of California as well as that of the junior author (at the University of Cincinnati). In addition duplicates of some of these species are at the New York Botanical Garden, the Mycological Collections of the Bureau of Plant Industry and the Farlow Herbarium. The junior author wishes to take this opportunity to thank the senior author for the use of laboratory facilities at the Herbarium of the University of California; he also wishes to thank John Thomas Howell for assistance with preparation of the latin diagnoses.

BOTANY DEPARTMENT,  
UNIVERSITY OF CALIFORNIA

# REVISIONARY STUDIES IN THE TROPICAL AMERICAN RUSTS OF PANICUM, PASPALUM AND SETARIA<sup>1</sup>

GEORGE B. CUMMINS

(WITH 24 FIGURES)

This paper presents the results of a taxonomic study of 14 species of the Uredinales parasitic upon hosts belonging to the genera *Panicum*, *Paspalum*, and *Setaria*. The rusts occur in the tropical and subtropical regions of North and South America. No attempt is made to account individually for the necessary changes in identification. In the case of exsiccati, however, the name of the set, and the number and name under which the rust was issued are given following the collector's name and number. Descriptions are given, together with synonymy. Where adequate material made it possible, photomicrographs of the teliospores of type specimens provide the illustrations.

Perhaps no group of rusts has been more confusing than that on grasses of the tribe Paniceae. This has been due to the scarcity of telia or to a failure to recognize their presence, and to the frequent comingling of more than one species in a single collection. Failure to recognize the presence of telia occurred in species whose telia are small and covered by the epidermis, as in *Puccinia dolosa*, *P. circumdata*, *P. catervaria*, *Uromyces leptodermus* and *U. Puttemansii*. Comingling of more than one species was primarily responsible for the confusion of *Angiopsora compressa* and *P. dolosa* with *P. substriata*, *P. Puttemansii* with *P. levis*, and led to the conception that *P. paspalicola* (*P. tubulosa*) was a species characterized by variable uredia. The variability in paraphyses and in the size and pigmentation of the urediospores, described for *P. tubulosa* (6), resulted from an attempt to include several species under a single name. Thus, the incurved, thick-walled paraphyses and nearly colorless urediospores be-

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longed to *A. compressa*, the hyphoid paraphyses belonged mainly to *P. dolosa*, and the telia belonged to *P. substriata*.

The rusts discussed in this paper are divisible into two groups. In the first the telia are small, inconspicuous and remain covered by the epidermis. In the second group the telia early rupture the epidermis and produce pulvinate and usually conspicuous sori. The aecial stage is known only for *P. substriata*.

#### SPECIES WITH INDEFINITELY COVERED TELIA

UROMYCES LEPTODERMUS Sydow, Ann. Myc. 4: 430. 1906. (FIGS. 7, 8.)

(*Uredo Panici* P. Henn. Hedwigia 43: 165. 1904; *Puccinia* (?) *panicicola* Arth. Bull. Torrey Club 34: 586. 1908; *Uredo Eriochloae* Speg. Anal. Mus. Nac. Buenos Aires 19: 319. 1909; *Uredo eriochloana* Sacc. & Trott. Syll. Fung. 21: 810. 1912; *Nigredo leptoderma* Arth. N. Am. Flora 7: 224. 1912; *Uredo Panici-maximi* Rangel, Arch. Mus. Nac. Rio de Janeiro 18: 160. 1916.)

Aecial stage unknown. Uredia amphigenous, elliptic or oval, 0.2–0.5 mm. long, cinnamon-brown, the epidermis opening widely by longitudinal rupture; urediospores broadly obovoid or broadly ellipsoid, (20–)23–27  $\times$  (25–)27–33(–35)  $\mu$ ; wall 1.5–2  $\mu$  thick, cinnamon-brown, closely and rather finely echinulate; pores 3, equatorial. Telia amphigenous, scattered, oval or oblong, 0.2–0.4 mm. long, blackish, remaining covered by the epidermis; teliospores variable due to pressure in the compact, covered sori, angularly globoid or obovoid, 16–21  $\times$  19–27  $\mu$ ; wall light chestnut- or golden-brown, uniformly 1–1.5  $\mu$  thick, smooth; pedicel colorless, usually shorter than spore, rather fragile.

MATERIAL EXAMINED: *Eriochloa annulata* Kunth: ARGENTINA: Spegazzini (type of *Uredo Eriochloae* Speg.). *E. Lemmoni* Vasey & Scribn.; MEXICO: Holway 3199. *E. polystachya* H.B.K.; VENEZUELA: Kern & Toro. *E. punctata* Ham.; TRINIDAD: Seaver 3193. *E. subglabra* (Nash) Hitchc.; PUERTO RICO: Earle 359; Seaver & Chardon 1306; Stevens 7605; Stevenson 3938; Whetzel, Kern & Toro 2125, 2205, 2206, 2353; Whetzel & Olive 398, 399, 400, 401, 402, 403, 404. *Panicum barbinode* Trin.; CUBA: Baker (Barth. Fungi Columb. 2671) (type of *Puccinia panicicola* Arth.); Britton & Wilson 14715, 15357; Earle 820;

Holway; Horne; Johnston 425; EL SALVADOR: Standley 19677; GUATEMALA: Holway 12; Kellerman 5364; MEXICO: Holway 3045 (Barth. N. Am. Ured. 857); PANAMA: Bethel; PERU: Holway 790; Rose 18723; PUERTO RICO: Hioram 360; Kern & Toro 37, 44; Stevens 350, 350 bis, 447, 480, 4560, 7122, 7168, 7199; ST. CROIX: Seaver 880; U. S. A.: Arthur; Bessey 65. *P. maximum* Jacq.; BRAZIL: Holway 1012 (Reliq. Holw. 101 as *P. tubulosa*), 1033 (Reliq. Holw. 103 as *P. levis*); Rangel 749 (type of *Uredo Panici-maximi* Rangel); GUATEMALA: Standley 64716. *P. purpurascens* Raddi; U. S. A.: Clover 1511. *P. texanum* Buckl.; U. S. A.: Shear. *Setaria geniculata* (Lam.) Beauv.; CUBA: Britton & Wilson 15439; Jennings 154; Johnston 483, 558, 762; Shafer 11795; JAMAICA: Britton 1659; PANAMA: Bethel; Carleton 23; PUERTO RICO: Whetzel, Kern and Toro 2351, 2352; Whetzel & Olive 438; Stevens 9182; U. S. A.: Hitchcock 512. *S. verticillata* (L.) Beauv.; BERMUDA: Brown & Britton 116, 302; VENEZUELA: Toro 38.

In a recent paper Thurston (18) pointed out the differences between *U. leptodermus* and *U. costaricensis* Syd. He concluded that *U. costaricensis* should be maintained as a species and that it is restricted to *Lasiacis*, while *U. leptodermus* occurs on *Panicum*. He cited two North American collections, both on *P. barbinode* and both with telia.

In the present study telia and teliospores which agree with those of *U. leptodermus* were found on *Eriochloa subglabra* from Puerto Rico (Earle 359, Whetzel & Olive 401), on *Panicum barbinode* from Cuba (Baker 7113, Horne s.n., Johnston 425), El Salvador (Standley 19677), Guatemala (Holway 12, Kellerman 5364) and Mexico (Holway 3045), on *P. purpurascens* from Texas (Clover 1511), on a tall grass from the Dominican Republic (Chardon 1137) and on *Setaria geniculata* from Cuba (Shafer 11795). The specimens on *Setaria* and *Eriochloa* were found under *P. substriata* and were so published in the North American Flora. Arthur first (3) cited *Eriochloa* as a host under *P. substriata* in 1917 and later (5, 6) placed the concerned rust names in the synonymy of the species.

Only one collection on *Setaria* was seen with telia and, since there is some variation in the uredial collections, some of the



FIG. 1, free-hand section of a telium of *Uromyces sepultus* Mains (= *U. Puttemansii* Rangel) on *Setaria tenax* (from type); 2, teliospores of *U. sepultus* (from type); 3, free-hand section of a telium of *Uromyces niteroyensis* Rangel.

specimens may belong elsewhere. The urediospores of *Uromyces Setariae-italicae* (Diet.) Yosh., for example, are generally similar to those of *U. leptodermus* but no teliospores with the wall thickness of that species have been found in America. Arthur (6, p. 746) placed *U. Setariae-italicae* in the synonymy of *U. leptodermus*. The uredia of *U. niteroyensis* (= *U. Puttemansii*) which Arthur (*l.c.*) also placed under *U. leptodermus* are longer covered by the epidermis and the urediospores are larger than in *U. leptodermus*, in addition to the apically thickened wall of the teliospores of the former. In *Puccinia catervaria* the urediospores are smaller and have four pores, while in *P. Chaetochloae* the spores are larger and remain more persistently covered by the epidermis. Although *Uredo Panici-maximi* is given as a synonym, as was done by Arthur (*l.c.*), it is somewhat doubtful whether this is correct. In spite of the characters pointed out above, it will remain difficult to identify uredial collections and it is probable that the last word remains to be said concerning the morphological limits of *U. leptodermus*.

No aecial stage has been demonstrated for *U. leptodermus* and the only clue to a possible alternate stage is provided by Kern (10) who writes: "Field evidence indicated a possible connection between the rust on *Eriochloa polystachya* and the *Aecidium Serjaniae* (Kern & Toro 1751)."

UROMYCES PUTTEMANSII Rangel, Arch. Mus. Nac. Rio de Janeiro 18: 159. 1916. (FIGS. 1-3.)

(*Uromyces niteroyensis* Rangel, Arch. Mus. Nac. Rio de Janeiro 18: 160. 1916; *Uromyces sepultus* Mains, Carnegie Inst. Washington Publ. 461: 99. 1935.)

Aecial stage unknown. Uredia amphigenous or mainly hypophyllous, scattered, elliptic, 0.2-0.6 mm. long, cinnamon-brown, the epidermis opening by a longitudinal slit or circumcissally, the epidermal cap then semi-persistent; paraphyses mainly peripheral

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(= *U. Puttemansii*) on *Setaria* sp. (from type); 4, teliospores of *Puccinia substriata* Ellis & Barth. on *Paspalum paniculatum* (from Holway 1679); this collection was closely associated in the field with *Aecidium tubulosum*; 5, free-hand section of a telium of *P. substriata* on *Paspalum setaceum* (from type); 6, teliospores of *Puccinia Pilgeriana* P. Henn. (= *P. substriata*) on *Paspalum* sp. (from type).  $\times 700$ .





FIG. 7, teliospores of *Uromyces leptodermus* Syd. on *Panicum barbinode* (from Kellerman 5364); 8, teliospores of *U. leptodermus* Syd. on *Eriochloa subglabra* (from Whetzel & Olive 401); 9, amphispores (?) of *Puccinia substriata* ? on *Paspalum trachycauleon* (from Tamayo 3767); 10, teliospores of *Puccinia araguata* Kern on *Paspalum microstachyum* (from type); 11, teliospores of *Puccinia Huberi* P. Henn. on *Panicum trichoides* (from Whetzel & Olive 414); 12, free-hand section of a telium of *Puccinia dolosa* Arth. & Fromme on *Paspalum tenellum* (from type); 13, teliospores of *Puccinia circumdata* Mains on *Panicum fasciculatum* (from type).  $\times 700$ .

and clavate, yellowish, thin-walled, inconspicuous; urediospores obovoid or ellipsoid,  $20-27 \times (26-)29-38(-42) \mu$ ; wall  $1.5-2 \mu$  thick, cinnamon- or dark cinnamon-brown, prominently echinulate; pores 3, perhaps rarely 2 or 4, equatorial. Telia mainly hypophyllous, loosely grouped or scattered, oblong or linear,  $0.2-2.0$  mm. long, blackish brown, remaining covered by the epidermis; teliospores variable due to pressure in the compact, covered sori, mostly obovoid, commonly angularly so,  $14-20 \times (19-)22-27(-30) \mu$ ; wall chestnut-brown,  $0.5-1 \mu$  thick at sides, thickened at apex to  $1.5-2.5 \mu$ , smooth; pedicel persistent, usually shorter than spore, pale yellowish or golden.

MATERIAL EXAMINED: *Setaria caespitosa* Hack. & Arech.: URUGUAY: Holway 2016. *S. leiantha* Hack.; ARGENTINA: Holway 2035. *S. paniculifera* (Steud.) Fourn. (*Chaetochloa sulcata* Hitchc.); PANAMA: Carleton 16; Johnston. *S. poiiretiana* (Schult.) Kunth; BRAZIL: Holway 1720. *S. rariflora* Mikan.; BRAZIL: Holway 1090. *S. setosa* (Sw.) Beauv.; CUBA: Rugel 880. *S. tenax* (Rich.) Desv. (*S. onurus* Griseb.); BRAZIL: Holway 1013, 1474 (Reliq. Holw. 102, 119 as *U. leptodermus*); BRITISH HONDURAS: Mains 4029; CUBA: Britton & Wilson 29; Johnston 301; Shafer 3020; Taylor 232; JAMAICA: Harris 12167; MEXICO: Swallen 2440 (type of *U. sepultus* Mains). *S. sp.*; BRAZIL: Rangel 1172 (type of *U. niteroyensis* Rangel).

Holway's South American collections in the above list were reported by Arthur (5) as *U. leptodermus*, under which he cited *U. niteroyensis* as a synonym. He discussed *U. Puttemansii* and *U. Panici-sanguinalis* in connection with *U. leptodermus* but reached no conclusion concerning their identity. Mains (l.c.) pointed out Arthur's error, with regard to Reliquiae Holwayanae nos. 102 and 119, when he published *U. sepultus*. The North American collections were separated from *Puccinia substriata*. In the 18 specimens studied telia were found on 11, including the type of *U. niteroyensis*. There appear to be no constant or substantial differences in the morphology of the various collections.

*Uromyces Puttemansii* is believed to be the correct name although this belief is based upon Rangel's description and figures (l.c., pl. 5, figs. 6-10) and not upon an examination of the type, which was not available. Rangel did not designate the type specimen and cited as hosts *Setaria asperifolia* and *Panicum*

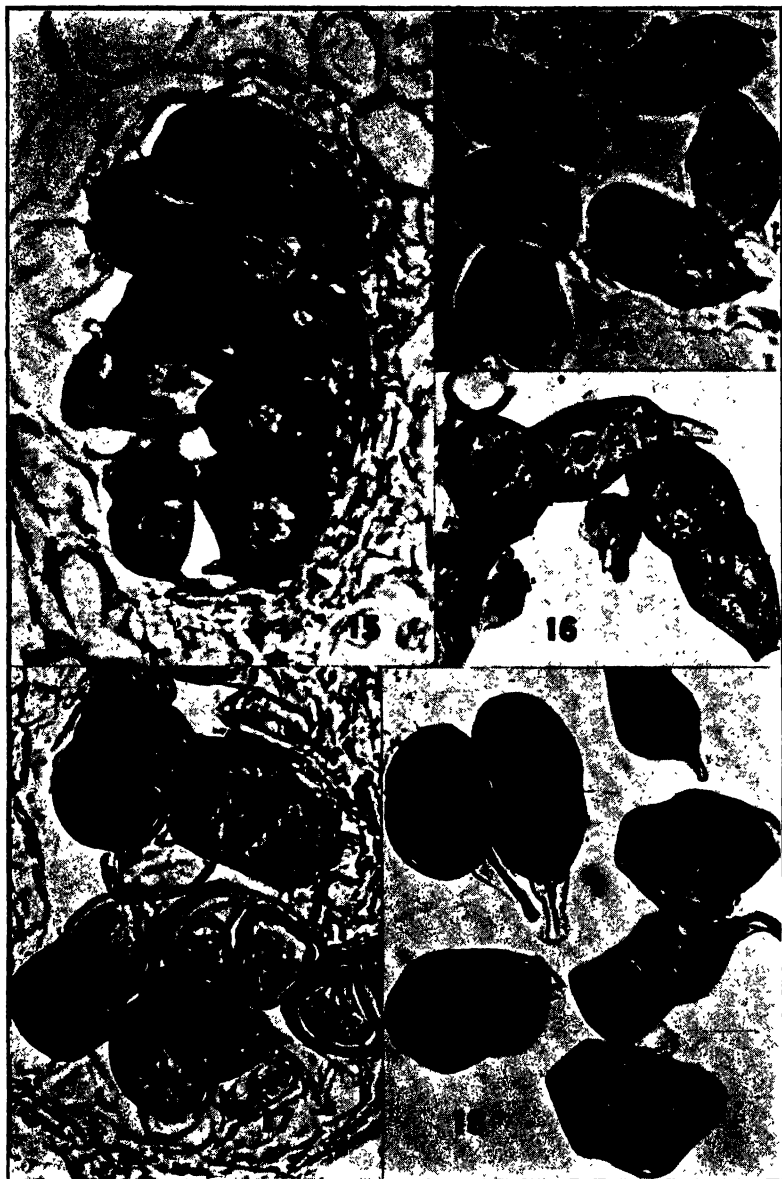


FIG. 14, teliospores of *Puccinia Puttemansii* P. Henn. on *Panicum* sp. (from type); 15, free-hand section of a telium of *Puccinia Chaetochloae* Arth. on *Setaria macrosperma* (from type); 16, teliospores of *P. Chaetochloae* on *Paspalum floridanum* (from Bartholomew 7608); 17, free-hand section of a telium of *Puccinia catervaria* Cum. on *Setaria geniculata* (from type); 18, teliospores of *P. catervaria* (from type).  $\times 700$ .

*melinis*, in that order. The numbers of these collections are 1211 and 1212, given in that order and both from Paqueta, Rio de Janeiro, June 1914. One would assume that no. 1211 would apply to the *Setaria* but there is a specimen (no. 1211), in the Arthur Herbarium, sent by Rangel, which is labelled *Panicum melinis*. The specimen on *Setaria* is presumably no. 1212, therefore. This is confusing enough but Hitchcock believed the host of no. 1211 to be *Digitaria sanguinalis* (see Arthur, 5) and Arthur decided, with justification, that the rust was identical with the type of *U. Panici-sanguinalis*. Furthermore, the urediospores do not agree with those figured by Rangel as from *Panicum melinis*. No telia are present. Perhaps a mixture of hosts is the correct explanation for this confusing situation.

Under his description of *U. niteroyensis* Rangel (*l.c.*) notes "A *U. Puttemansii* praecique uredosporis diversa" and his illustrations show teliospores and paraphyses like those figured for *P. Puttemansii* and one smaller urediospore. The figure of the urediospore appears to be an end view. His measurements for the urediospores of *U. niteroyensis* ( $20-26 \times 24-28 \mu$ ) are smaller than he gives for *U. Puttemansii* ( $24-28 \times 24-40 \mu$ ). Dr. Thurston examined our type specimen in 1932 and his notes give the urediospores as  $19-23 \times 24-27 \mu$ , the measurements based upon four spores. I did not see urediospores in sections of the telia nor uredia on the rather fragmentary specimen.

Because of the apparent identity of the specimens examined with the figures published by Rangel I believe adoption of the name *U. Puttemansii* is justified.

*U. Puttemansii* differs from *U. leptodermus* in having teliospores with persistent pedicels, an apical wall noticeably thickened and larger urediospores. The large urediospores also separate it from *P. catervaria* but make confusion with *P. Chaetochloae* possible, except when telia are present. The uredia of *P. Chaetochloae* are longer covered, however, the ruptured epidermis is more conspicuously persistent as a cap, and the urediospores tend to be more angular.

PUCCINIA CHAETOCHLOAE Arth., Bull. Torrey Club 34: 585. 1907. (FIGS. 15, 16.)

(*Uredo Chaetochloae* Arth. Bull. Torrey Club 33: 518. 1906; *Puccinia Maublancii* Rangel, Arch. Mus. Nac. Rio de Janeiro 18: 159. 1916; *Dicaeoma Chaetochloae* Arth. & Fromme, N. Am. Flora 7: 288. 1920.)

Aecial stage unknown. Uredia amphigenous, scattered, oval or linear 0.5–2.0 mm. long, cinnamon-brown, the epidermis opening by a longitudinal slit or by circumcised rupture, the epidermal cap then long persistent; paraphyses thin-walled, hyaline or yellowish, cylindric, inconspicuous; urediospores broadly ellipsoid, ellipsoid or oblong, commonly angular, variable in size, (19–)22–27(–30)  $\times$  (26–)30–38(–43)  $\mu$ ; wall cinnamon-brown, 2  $\mu$  thick, rather sparsely and strongly echinulate; pores 3 or 4, equatorial. Telia amphigenous, oblong or linear, 0.5–1.0 mm. long, blackish brown, remaining covered by the epidermis; teliospores irregular due to pressure in the compact, covered sorus, clavate, oblong or ellipsoid, rounded or somewhat obtuse above, usually narrowed below, slightly constricted at septum, (18–)20–26  $\times$  (29–)32–40(45)  $\mu$ ; wall chestnut-brown, 1.5  $\mu$  thick at sides, thickened at apex to 2–4  $\mu$ , smooth; pedicel, sometimes laterally placed, persistent, yellowish or golden-brown. Mesospores occasional.

MATERIAL EXAMINED: *Paspalum arundinaceum* Poir.: DOMINICAN REPUBLIC: Ekman (Ciferri, Mycofl. Doming. Exs. 105). *P. densum* Poir.; BRAZIL: Rangel 1162 (type of *P. Maublancii* Rangel). *P. floridanum* Michx.; U. S. A.: Bartholomew (Barth., N. Am. Ured. 2776 as *P. substriata*); Lewis & Tharp; Long 2745, 2821. *P. glabrum* Poir.; PUERTO RICO: Stevens 1732. *P. milligrana* Schrad.; PUERTO RICO: Whetzel, Kern & Toro 2331; Whetzel & Olive 439. *P. secans* Hitchc. & Chase; PUERTO RICO: Holway 20. *Setaria geniculata* Beauv.; VENEZUELA: Chardon, Toro & Alamo 163. *S. macrosperma* (Schribn. & Merr.) Schum.; U. S. A.: Bessey 41, 59; Holway (type).

Because of a paucity of telia it has been difficult to reach a decision concerning the morphological limitations, the hosts and the distribution of this species. Telia are present on *Setaria macrosperma* in three Florida specimens, including the type, on *P. densum* in the type of *Puccinia Maublancii* from Brazil and on *P. floridanum* from Oklahoma. The Oklahoma specimen was

issued as no. 2776 in Bartholomew, North American Uredinales as *Puccinia substriata*. In these specimens the telia are long covered, the spores are variable and angular, and their walls are rather brittle and easily crushed. The uredia also are tardily dehiscent, with the elevated epidermis usually conspicuous. While the species is probably less closely related to *P. substriata* than to *P. dolosa*, *P. circumdata*, and *P. catervaria* it is more apt to be confused with *P. substriata*, and *Uromyces Puttemansii* in the absence of telia, because of the large urediospores.

Microscopically and macroscopically the telia of *P. Chaetochloae* are similar to those of *P. circumdata*, *P. dolosa*, and *P. catervaria*. In size the teliospores are close to those of *P. dolosa* but larger than those of *P. catervaria* and *P. circumdata*. The urediospores, however, are larger, especially longer, have thicker walls, and approach those of *P. substriata*. It has been difficult with uredial collections to decide whether specimens should be referred to *P. Chaetochloae* or to *P. substriata*. It seems to be rather constantly true, however, that the urediospores of *P. Chaetochloae* are angularly ellipsoid or oblong-ellipsoid while those of *P. substriata* are broadly ellipsoid or obovoid and not angular. The pores in *P. substriata* tend to be slightly below the equator, which is not the case in *P. Chaetochloae*, and are usually four, less commonly three or five, in number.

***Puccinia catervaria* Cummins, sp. nov. (FIGS. 17, 18).**

Urediis amphigenis, sparsis, paraphysibus periphericis dilute brunneis inconspicuis; urediosporae late ellipsoideae vel obovoideae,  $19-24 \times 24-29 \mu$ ; membrana cinnamomeo-brunnea  $1.5-2 \mu$  cr., moderate echinulata; poris germ. 4, aequatorialibus. Teliis plerumque epiphyllis, sparsis, atrobrunneis, diutius tectis; teliosporae variabiliter angulariter ellipsoideae, oblongo-ellipsoideae vel clavatae,  $(18-)20-23 \times 26-33 \mu$ ; membrana  $1-1.5 \mu$  cr., ad apicem  $2-3.5 \mu$  cr., castaneo-brunnea, levi; pedicello sporam brevior, brunneolo, persistenti.

On *Setaria geniculata* in Bolivia.

Aecial stage unknown. Uredia amphigenous, scattered, elliptic, 0.2–0.7 mm. long, cinnamon-brown, with peripheral cylindric or clavate, thin-walled, pale brownish and rather inconspicuous paraphyses, the epidermis opening widely by longitudinal rupture; urediospores broadly ellipsoid or obovoid,  $19-24 \times 24-29 \mu$ ; wall cinnamon-brown, moderately echinulate,  $1.5-2 \mu$  thick; pores 4, equatorial. Telia mainly epiphyllous, scattered, minute,

oblong, 0.1–0.3 mm. long, blackish brown, remaining covered by the epidermis; teliospores variable and usually angular due to pressure in the compact, covered sori, ellipsoid, oblong-ellipsoid or clavate, more or less rounded at each end, constricted at the septum,  $(18\text{--}20\text{--}23 \times 26\text{--}33 \mu$ ; wall chestnut-brown,  $1\text{--}1.5 \mu$  thick at sides, thickened apically to  $2\text{--}3.5 \mu$ , smooth; pedicel, frequently lateral, shorter than the spore, brownish, persistent.

MATERIAL EXAMINED: *Setaria geniculata* (Lam.) Beauv.: BOLIVIA: Cochabamba, Feb. 28, 1920, Holway 348 (type) (Reliq. Holw. 53 as *Puccinia levis*).

This rust was included by Arthur (5) under *Puccinia levis*, a species with which it has no characters in common. The presence of telia was not recognized.

Morphologically, *P. catervaria* is related, perhaps too closely, to *P. circumdata* which appears, however, to be restricted to *Panicum fasciculatum*. In addition to the apparent host restriction, *P. catervaria* has urediospores with four pores and the spores lack the triangular shape of those of *P. circumdata*. It seems best, without knowledge of the aecial stages, to maintain *P. circumdata* and *P. catervaria* as separate species.

PUCCINIA CIRCUMDATA Mains, Carnegie Inst. Washington Publ. 461: 101. 1935. (FIG. 13.)

Aecial stage unknown. Uredia amphigenous, scattered, elliptic or oblong-linear, 0.3–0.8 mm. long, cinnamon-brown, the epidermis ruptured by a longitudinal slit; hyaline or brownish, clavate or cylindric, thin-walled paraphyses present but not conspicuous; urediospores ellipsoid or obovoid, triangular in end view,  $19\text{--}24 \times 23\text{--}32 \mu$ ; wall  $1\text{--}1.5 \mu$ , light cinnamon- or golden-brown, finely echinulate; pores 3, equatorial, in the angles. Telia amphigenous, oval or oblong, 0.2–0.4 mm. long, blackish brown, remaining covered by the epidermis; teliospores irregular due to pressure in the compact, covered sori, oblong, oblong-ellipsoid, oblong-clavate or ellipsoid, usually angular, slightly constricted at septum,  $17\text{--}24\text{--}(26) \times 26\text{--}33\text{--}(36) \mu$ ; wall brittle and easily crushed,  $1\text{--}1.5 \mu$  thick at sides, slightly thickened at apex to  $2\text{--}3 \mu$ , chestnut-brown, smooth; pedicel about one-half length of spore or less, hyaline, sometimes laterally attached. Mesospores few or, in some collections, abundant.

MATERIAL EXAMINED: *Panicum fasciculatum* Sw.: CUBA: Johnston 641; MEXICO: Swallen 2389, 2592 (type); PANAMA:

Carleton 129; Johnston 2562; Killip 4148; PUERTO RICO: Seaver & Chardon 2057; Stevens 7816; Whetzel & Olive 445.

Although first described by Mains this species was previously reported under other names. Arthur reported it in 1916 (2), 1917 (3) and 1918 (8) as *P. Huberi*. The records were reported similarly in 1920 by Arthur and Fromme (6, p. 287). In 1926 Arthur (6, p. 774) reduced *P. Huberi* to synonymy under *P. levis*. All collections were on *P. fasciculatum*. Mains (*l.c.*) reported *Paspalum yucatanum* as a host but I consider it to be *P. dolosa*.

No other rust on *Panicum* can well be confused with *P. circumdata*. *P. catervaria* is closely related but it parasitizes *Setaria* and has urediospores with four pores. *P. dolosa*, on *Paspalum*, has similar telia and similarly delicate and brittle, but larger teliospores. The urediospores also are triangular in end-view and have three pores but are smaller. Mains (*l.c.*) enumerated the differences between *P. circumdata* and *P. Chaetochloae*.

PUCCINIA DOLOSA Arth. & Fromme, Torreya 15: 262. 1915.  
(FIG. 12.)

Aecial stage unknown. Uredia amphigenous or often mainly epiphyllous, evenly scattered, elliptic, 0.2–0.4 mm. long, pale cinnamon-brown, the epidermis rupturing by a longitudinal slit; paraphyses mainly peripheral, hyphoid or cylindric, hyaline or pale yellowish, inconspicuous; urediospores usually obovoid, triangular in end view, 16–20(–24)  $\times$  19–25(–29)  $\mu$ ; wall 1–1.5  $\mu$  thick, light cinnamon- or golden-brown, finely echinulate; pores 3, equatorial, in the angles. Telia amphigenous or mainly epiphyllous, scattered, oval or elliptic, 0.1–0.5 mm. long, blackish brown, remaining covered by the epidermis; teliospores variable due to pressure in the compact, covered sori, oblong, oblong-clavate or clavate, usually angular, broadly rounded or obtuse above, usually narrowed below, slightly constricted at septum, 17–23(–26)  $\times$  28–40(–45)  $\mu$ ; wall brittle and easily crushed, 1–1.5  $\mu$  thick at sides, thickened to 2–4  $\mu$  at apex, chestnut-brown, smooth; pedicel one-half as long as spore or less, yellowish or hyaline, sometimes laterally placed. Mesospores rare.

MATERIAL EXAMINED: *Paspalum mandiocanum* Trin.: BRAZIL: Holway 1675. *P. multiflorum* Doell.; BRAZIL: Holway 1478, 1642. *P. paniculatum* L.; BRAZIL: Holway 1464, 1469 (Reliq. Holw. 116, 117 as *P. substriata*), 1597, 1612 (Reliq. Holw. 131



as *P. substriata*), 1650, 1664, 1731, 1773, 1781, 1793; VENEZUELA: Barrus & Müller 3629; Chardon 1120; Müller 2028, 2084; COSTA RICA: Stevens 425; MEXICO: Hitchcock 6874; Holway 3514; PANAMA: Carleton 232; PUERTO RICO: Thomas; Whetzel & Olive 391, 392. *P. plicatulum* Michx.; BRAZIL: Holway 1321 (Reliq. Holw. 114 as *P. substriata*), 1504, 1647, 1659 (Reliq. Holw. 136 as *P. tubulosa*); PUERTO RICO: Whetzel, Kern & Toro 2333. *P. Regnelli* Mez.; BRAZIL: Holway 1554 (Reliq. Holw. 124 as *P. substriata*), 1602, 1643 (Reliq. Holw. 126, 133 as *P. substriata*), 1651, 1662, 1685 (Reliq. Holw. 139 as *P. substriata*), 1696. *P. tenellum* Willd.; MEXICO: Holway (type) (Syd. Ured. 1986), 3065. *P. Usteri* Hack.; BRAZIL: Holway 1553 (Reliq. Holw. 123 as *P. tubulosa*). *P. virgatum* L.; BRAZIL: Holway 1628 (Reliq. Holw. 132 as *P. substriata*); CUBA: Johnston 307. *P. sp.*; BRAZIL: Holway 1280 (Reliq. Holw. 112 as *P. substriata*), 1697; GUATEMALA: Johnston 1696.

*P. dolosa* was published in 1915 by Arthur and Fromme (*l.c.*) but reduced to synonymy under *P. Huberi* in 1920 (6, p. 287). In 1925, Arthur (5) reduced *P. Huberi* to synonymy under *P. levis* and removed *P. dolosa* to the synonymy of *P. substriata*. Other than in these records *P. dolosa* seems to have been neglected.

The long-covered, small telia serve to separate *P. dolosa* from *P. Huberi*, *P. Puttemansii*, *P. substriata*, *P. araguata*, and *P. levis*. The telia can be easily overlooked but were found in two-thirds of the specimens. Failure to recognize the telia has probably been due in part to their subepidermal position and small size and in part to the brittle nature of the walls of the teliospores. In mounts made by scraping or crushing the teliospores are apt to be fragmented beyond recognition.

The character of brittleness is possessed in a like degree by the teliospores of *P. circumdata* and *P. catervaria* and to a lesser degree by those of *P. Chaetochloae*. *P. dolosa* is separable from *P. Chaetochloae* because of the small, thin-walled urediospores and from *P. catervaria* because of smaller, 3-pored urediospores and larger teliospores. The urediospores of *P. circumdata* likewise are angular and have three pores but are larger, while the teliospores are smaller.

## SPECIES WITH EARLY-EXPOSED, PULVINATE TELIA

PUCCINIA SUBSTRIATA Ellis & Barth. *Erythea* 5: 47. 1897.  
(FIGS. 4-6.)

(*Dicaeoma substriatum* Arth., Résult. Sci. Congr. Bot. Vienne 344. 1916; *Puccinia Pilgeriana* P. Henn. Bot. Jahrb. 40: 226. 1908; *Uredo cubangoensis* Rangel, Arch. Mus. Nac. Rio de Janeiro 18: 160. 1916; *Puccinia tubulosa* Arth. Am. Jour. Bot. 5: 464. 1918, in part; *Dicaeoma tubulosum* Arth. & Fromme, N. Am. Flora 7: 288. 1920, in part.)

AECIAL STAGE: *Aecidium tubulosum* Pat. & Gaill.; cultures made by Thomas (17). Uredia amphigenous or mainly hypophyllous, scattered, elliptic, 0.3-0.8 mm. long, cinnamon-brown, the epidermis opening broadly by longitudinal or irregular rupture; urediospores broadly ellipsoid or obovoid, (20-)23-30  $\times$  (25-)28-36  $\mu$ ; wall cinnamon-brown, 1.5-2  $\mu$  thick with a tendency to be slightly thicker above, moderately echinulate; pores usually 4, less commonly 3 and rarely 5, equatorial or slightly below. Telia amphigenous or mainly hypophyllous, scattered, early naked, pulvinate, chestnut-brown or blackish brown, round, oval or oblong, 0.3-0.8 mm. long; teliospores oblong-ellipsoid or clavate, rounded or somewhat obtuse above, narrowed below, slightly constricted at septum, 19-26(-29)  $\times$  (29-)33-50  $\mu$ ; wall chestnut-brown or frequently golden-brown in tropical collections, 1.5-2  $\mu$  thick at sides, 3-7  $\mu$  at apex, smooth; pedicel about one-half as long as spore, hyaline or yellowish, persistent. Mesospores and 3-celled spores rarely present.

MATERIAL EXAMINED: *Paspalum affine* Steud.: GUATEMALA: Standley 63781. *P. Bushii* Nash; U. S. A.: Learn. *P. ciliatifolium* Michx.; U. S. A.: Arthur; Holway; Lewis & Tharp. *P. conjugatum* Berg.; PUERTO RICO: Stevens 9237. *P. Curtisianum* Steud.; U. S. A.: Hitchcock 500. *P. denticulatum* Trin.; U. S. A.: Arthur & Fromme 6308. *P. distichophyllum* H.B.K.; BRAZIL: Holway 1640, 1672. *P. distichum* L.; PERU: Holway 781 (Reliq. Holw. 94). *P. Hankeanum* Presl; PERU: Holway 786. *P. Humboldtianum* Fluegge; BOLIVIA: Holway 678, 712; PERU: Holway 782. *P. langei* (Fourn.) Nash; GUATEMALA: Standley 90063; U. S. A.: Clover 1656; VENEZUELA: Sydow (Fung. Exot. Exs. 775 as *P. paspali*). *P. malacophyllum* Trin.; BRAZIL: Holway 1645 (Reliq. Holw. 135 as *P. tubulosa*), 1646, 1725, 1873. *P. mandiocanum* Trin.; BRAZIL: Holway 1677, 1690,

Rangel 1143 (type of *Uredo cubangoensis* Rangel). *P. molle* Poir.; VENEZUELA: Chardon & Toro 509, Müller 2331. *P. paniculatum* L.; BOLIVIA: Holway 726; BRAZIL: Holway 1568 (Reliq. Holw. 125 as *P. tubulosa*), 1630, 1679; COSTA RICA: Bethel; DOMINICAN REPUBLIC: Ekman (Ciferri, Mycofl. Doming. Exs. 74 as *P. tubulosa*); GUATEMALA: Holway 595; PUERTO RICO: Stevens 293, 898, 4758, 7313, 8048, 8444, 8645; Stevenson 3995; Thomas 3 coll.; Whetzel, Kern & Toro 2324, 2335; Whetzel & Olive 393, 411; VENEZUELA: Chardon & Toro 503. *P. pilosum* Lam.; BRAZIL: Holway 1948. *P. plantagineum* Nees; BRAZIL: Holway 1937. *P. pruinatum* Trin.; BRAZIL: Holway 1482, 1644 (Reliq. Holw. 134 as *P. tubulosa*). *P. pubescens* Muhl.; U. S. A.: Cummins. *P. remotum* Remy; BOLIVIA: Holway 336 (Reliq. Holw. 51). *P. setaceum* Michx.; U. S. A.: Bartholomew (type) (E. & E. N. Am. Fungi 3577; Fungi Columb. 1186), (Syd., Ured. 1080), (Barth., N. Am. Ured. 2167), 7023; Bates 3052. *P. stramineum* Nash; U. S. A.: Bates (Barth., Fungi Columb. 4673). *P. trachycauleon* Steud.; VENEZUELA: Barrus 3738; Tamayo 3767; Whetzel & Müller 2845. *P. Usteri* Hack.; BRAZIL: Holway 1641, 1676. *P. virgatum* L.; PUERTO RICO: Whetzel, Kern & Toro 2330. *P. sp.*; BRAZIL: Holway 1727; Pilger (type of *P. Pilgeriana*); BRITISH HONDURAS: Mains 3799, 3863; PERU: Abbott; U. S. A.: Long 2740. *Setaria lutescens* (Weigel) F. T. Hubb.; U. S. A.: Clover 961. *Valota saccharata* (Buckl.) Chase; BOLIVIA: Holway 321, 368 (Reliq. Holw. 60 as *P. tubulosa*); CUBA: Johnston 1040; GUATEMALA: Holway 857; Kellerman 5368; PUERTO RICO: Whetzel, Kern & Toro 2122, 2127, 2308, 2346, 2347; Whetzel & Olive 394, 436, 447.

*P. substriata* is the only species in this paper whose aecial stage (*Aecidium tubulosum*) has been indicated by collectors and also proved by cultures. Field observations made by Whetzel and Olive (13) led them to believe that this *Aecidium* on *Solanum* was the alternate stage of *P. substriata* on *Paspalum* and their germination experiments proved it to be a true *Aecidium*. They credit Stevenson with having reached a similar conclusion. Holway observed close association between *A. tubulosum* and rusted *Paspalum*. Arthur (5) recorded these observations under *P. tubulosa*, since he (4) had previously concluded that the

species was distinct from *P. substriata*. In 1918, working in Puerto Rico, Thomas (17) proved the life cycle by experimental methods and reported his results as applying to *P. substriata*. Arthur (7) reported, under *P. paspalicola*, aecia on *Solanum elaeagnifolium* in Texas and on *S. carolinense* in Iowa. On Oct. 15, 1941, I obtained uredia and telia of *P. substriata* on *Paspalum pubescens* near Oaktown, in southern Indiana. This material was overwintered at Lafayette and plants of *S. carolinense*, grown from seed, were inoculated on May 5, 9 and 12, 1942. Pycnia developed May 19 followed by aecia June 1. The spores from these aecia measured  $18-23 \times 23-29 \mu$  and thus fall in the lower range of measurements for the tropical aecia on *Solanum*. This culture demonstrates that *P. substriata*, as it occurs on *Paspalum* in the United States, forms aecia on the genus *Solanum* as it does in the tropical regions.

Because of the availability of the type of *Uredo paspalicola* and the widespread presence of similar uredia on tropical species of *Paspalum*, often in association with uredia and telia of *P. substriata*, Arthur (4) and Arthur and Fromme (6, p. 288) published *U. paspalicola* as a synonym under the name, *P. tubulosa*. Arthur (4) made the new combination although Arthur and Fromme appear as co-authors in the Flora where they also recognized *P. substriata*, without synonyms, as a species. Later, Arthur (6, p. 774) added *P. Pilgeriana* P. Henn. to the synonymy of *P. tubulosa* and cited nine synonyms under *P. substriata*. The situation remained static until 1934 when Arthur (7) placed *P. tubulosa* under the new combination, *P. paspalicola* (P. Henn.) Arth.

In 1934, Mains (12) described the genus *Angiopsora* and included, by transfer, *Puccinia compressa* Arth. & Holw. Apparently Arthur did not recognize the similarity between *Uredo paspalicola* and the uredia of *P. compressa* when he (5) described *P. compressa*. This seems strange since he recorded uredial collections along with the type, but assigned identical uredial collections (Holway 1607, 1633) as well as collections (Holway 719; Reliq. Holw. 87) with telia to *P. tubulosa* (l.c., p. 174). Moreover, he assigned both uredial collections (Holway 1418, 1476) and telial collections (Holway 703) to *P. substriata* (l.c.,

p. 171, 172). *Uredo paspalicola* is synonymous with *Angiopsora compressa* and *P. tubulosa* becomes synonymous with *P. substriata*. Cummins (9) has published the synonymy, hosts and distribution of *A. compressa*.

Because of erumpent, compact telia *P. substriata* differs from *P. Chaetochloae* and *P. dolosa*. In so far as telia are concerned *P. substriata* has a general similarity to *P. araguata* but the teliospores of *P. araguata* are larger, especially broader, and the urediospores are thinner-walled and paler in color.

As recorded above, the urediospores of *P. substriata* tend to have the wall slightly thickened apically. This varies but is commoner in tropical collections. The apical thickening is not evident in the type but in a Venezuelan collection (Tamayo 3767) it is much exaggerated (FIG. 9) and accompanied by increased lateral wall thickness. I am inclined to believe that the latter collection is an amphisporic variant of *P. substriata*. The tendency of the germ pores to be slightly subequatorial is evident in the type, in most collections showing the apical thickening, and in the amphisporic form, but is not constant. The pores are strictly equatorial in some collections, as those on *Valota*. Some variation exists also in the number of pores, but they are usually four. In general those spores which show a tendency to be thickened apically also tend to be slightly larger. The teliospores in tropical collections, except on *Valota*, tend to be shorter than in the type.

These tendencies and variations are not sufficiently striking to justify further segregation. They can be evaluated with accuracy only after the species has been studied by cultural methods.

**PUCCINIA ARAGUATA** Kern, Mycologia 30: 544. 1938. (FIG. 10.)

(*Puccinia paspalicola* Kern, Thurston & Whetzel, Monogr.

Univ. P. Rico B. 2: 284. 1934 (Oct.). Not *P. paspalicola*

Arth. 1934 (June).

Aecial stage unknown. Uredia amphigenous, scattered, elliptic or linear, 0.5–1 mm. long, the epidermis rupturing longitudinally and remaining rather conspicuous, pale cinnamon- or golden-brown; urediospores obovoid or ellipsoid, 19–23(–25)  $\times$  27–35  $\mu$ ; wall pale golden or yellowish, 1–1.5  $\mu$  thick, finely

echinulate; pores obscure, equatorial, 4 where seen with certainty. Telia epiphyllous, scattered, oval or linear, 0.3–0.8 mm. long, blackish brown, pulvinate, surrounded by the upturned epidermis; teliospores broadly clavate or oblong-clavate, broadly rounded above, somewhat narrowed below, only slightly constricted at septum,  $(20-)\text{24--30} \times (40-)\text{44--53}(-63) \mu$ ; wall dark cinnamon- or light chestnut-brown,  $1.5\text{--}2.5 \mu$  thick at sides, thickened apically to  $4\text{--}9 \mu$ , smooth; pedicel broad, shorter than spore and usually broken at or near hilum.

MATERIAL EXAMINED: *Paspalum microstachyum* Presl: VENEZUELA: Chardon & Toro 600 (type).

*P. araguata* is a distinctive species with more the macroscopic appearance of *P. macra* Arth. & Holw. than of *P. substriata*. The teliospores are broader than those of *P. substriata* and of different shape than those of *P. macra*. The urediospores are paler than those of *P. substriata* and are distinct from the similarly colored spores of *P. macra* because of the equatorial pores.

PUCCINIA MACRA Arth. & Holw.; Arth. Am. Jour. Bot. 5: 465. 1918. (FIG. 23.)

(*Dicaeoma macrum* Arth. & Fromme, N. Am. Flora 7: 287. 1920.)

Accial stage unknown. Uredia mainly hypophyllous, oval or linear, 0.5–1 mm. long, scattered or in linear groups, orange or yellowish, the epidermis opening by longitudinal rupture and remaining more or less conspicuous; urediospores ellipsoid or broadly ellipsoid,  $23\text{--}29 \times 28\text{--}35 \mu$ ; wall  $1\text{--}1.5 \mu$  thick, yellowish, finely and rather sparsely echinulate; pores about 8, scattered, obscure. Telia hypophyllous and on sheaths, oval or oblong, 0.5–1.5 mm. long, scattered or in groups, early naked, pulvinate, blackish brown, sometimes with few brownish, hyphoid paraphyses; teliospores clavate, oblong-clavate or less commonly ellipsoid, rounded or rarely nearly truncate above, narrowed or rarely rounded below, slightly constricted at septum,  $20\text{--}28 \times (35-)\text{39--50}(-56) \mu$ ; wall chestnut-brown or somewhat paler,  $2 \mu$  thick at sides,  $5\text{--}8 \mu$  at apex, smooth; pedicel about as long as spore, golden, moderately thin-walled, persistent.

MATERIAL EXAMINED: *Paspalum candidum* (Humb. & Bonpl.) Kunth: BOLIVIA: Holway 697; COSTA RICA: Sydow 292; GUATEMALA: Holway 168 (type); VENEZUELA: Barrus & Müller 3625. *P. prostratum* Scribn. & Merr.; COLOMBIA: Chardon 816.

*P. macra* is distinctive because of the pale uredia, yellowish thin-walled urediospores with scattered pores and the large clavate teliospores. The species was recorded from Ecuador by Arthur (5) but the specimens have thick-walled, verrucose urediospores and are cited under *P. pseudoatra*.

***Puccinia pseudoatra* Cummins, sp. nov. (FIG. 21).**

Urediis amphigenis, seriatim dispositis vel sparsis, dilute cinnamomeo-brunneis; urediosporae globoideae,  $22-26 \times 23-27 \mu$ ; membrana aureo-vel pallide cinnamomeo-brunnea,  $2.5-3 \mu$  cr., verrucosa; poris germ. 7 vel 8, sparsis. Teliis urediis conformibus sed atro-brunneis, pulvinatis; teliosporae ellipsoideae,  $21-26 \times 29-37 \mu$ ; membrana castaneo-brunnea,  $2-3 \mu$  cr., ad apicem  $5-8 \mu$ ; pedicello flavidulo, persistenti, sporam aequantae vel longiore.

On *Paspalum pallidum*, *P. penicillatum*, *P. prostratum* in Bolivia and Ecuador.

Aecial stage unknown. Uredia amphigenous or sometimes only hypophyllous; in linear groups or scattered, oval or linear, 0.3–1.5 mm. long or longer by confluence, light cinnamon-brown, the epidermis rupturing longitudinally and remaining conspicuous; urediospores globoid, less often broadly ellipsoid,  $22-26 \times 23-27 \mu$ ; wall golden- or light cinnamon-brown, closely and finely verrucose, the beads uniting in irregular, labyrinthiform lines,  $2.5-3 \mu$  thick; pores 7 or 8 scattered. Telia like the uredia but blackish brown and pulvinate; teliospores ellipsoid, rounded at both ends or slightly narrowed below, only slightly constricted at septum,  $21-26 \times 29-37 \mu$ ; wall  $2-3 \mu$  thick at sides,  $5-8 \mu$  at apex, deep chestnut-brown, smooth; pedicel persistent, pale yellowish, relatively thin-walled, one or two times as long as spore.

On *Paspalum pallidum* H.B.K.: ECUADOR: Quito, Aug. 17, Aug. 30, 1920, Holway 909, 954 (type) (Reliq. Holw. 100 as *P. macra*). *Paspalum* aff. *pallidum*; ECUADOR: Ambato, 1920, Pachano 106, 108. *P. penicillatum* Hook.; ECUADOR: Quito, May 1890, Lagerheim. *P. prostratum* Scribn. & Merr.; BOLIVIA: Sorata, Apr. 12, 1920, Holway 507 (Reliq. Holw. 79 as *P. atra*).

The above specimens were reported by Arthur (5) variously as *P. panicophila*, *P. macra* and *P. atra*.

*P. pseudoatra* has nothing in common with *P. macra*. The urediospores agree with those of *P. Setariae* in type of sculpture and arrangement of pores but are smaller, as are the teliospores. The teliospores have the shape of those of *P. atra* but are smaller,

while the urediospores are smaller and have scattered pores. A somewhat similar rust on *Valota insularis* is discussed under *P. atra*.

PUCCINIA ATRA Diet. & Holw.; Holway, Bot. Gaz. 24: 29. 1897.  
(FIGS. 19, 20, 22.)

(*Puccinia esclavensis* Diet. & Holw.; Holway, Bot. Gaz. 24: 29. 1897; *Dicaeoma atrum* Arth. Résult. Sci. Congr. Bot. Vienne 344. 1906; *Dicaeoma esclavensis* Arth. Résult. Sci. Congr. Bot. Vienne 344. 1906; *Puccinia panicophila* Speg. Anal. Mus. Nac. Buenos Aires 19: 300. 1909.)

Aecial stage unknown. Uredia amphigenous or mainly hypophyllous, scattered or usually in linear groups, oval or linear, 0.5–1 mm. long or longer by confluence, cinnamon-brown, the epidermis rupturing longitudinally and remaining more or less conspicuous; urediospores globoid, broadly ellipsoid, ellipsoid or obovoid, (22–)24–29  $\times$  (25–)27–32(–35)  $\mu$ ; wall cinnamon- or golden-brown, 2.5–3.5  $\mu$  thick, closely and finely verrucose, the beads more or less united in irregular labyrinthiform lines; pores 4–6, equatorial or somewhat scattered in occasional spores. Telia like the uredia but blackish-brown and pulvinate; teliospores ellipsoid, rounded at both ends or slightly narrowed below, slightly or not constricted at septum, 22–29  $\times$  30–41  $\mu$ ; wall deep chestnut-brown, smooth, 2.5–3.5  $\mu$  thick at sides, 4–8  $\mu$  at apex; pedicel one and one-half or two times as long as spore, persistent, yellowish, thick-walled.

MATERIAL EXAMINED: *Leptoloma cognatum* (Schultes) Chase: U. S. A.: Clemens. *Panicum bulbosum* H.B.K.; MEXICO: Hitchcock; Holway (type of *P. esclavensis* D. & H.), 3140; Pringle 6418, *P. bulbosum sciaphilum* (Rupr.) Hitchc. & Chase; MEXICO: Hitchcock; U. S. A.: Holway (Syd., Ured. 1308); Long 5278a; Wilcox. *Paspalum Helleri* Nash; PUERTO RICO: Stevens 8999. *P. sp.*; ECUADOR: Holway 824a. *Pennisetum bambusiforme* Hemsl.; MEXICO: Pringle 6075. *P. chilense* (Desv.) Jacks.; BOLIVIA: Holway 438 (Reliq. Holw. 70), 605. *Setaria Grisebachii* Four.; MEXICO: Holway (type), 3040, 3153, 3165, 3521. *Valota insularis* (L.) Chase; BRAZIL: Holway 1082, 1152, 1290 (Reliq. Holw. 113), 1704; GUATEMALA: Holway 205; Kellerman 5469; MEXICO: Holway 3638; PUERTO RICO: Seaver 825; Whetzel, Kern & Toro 2250, 2260. *V. saccharata* (Buckl.) Chase;



ARGENTINA: Spegazzini (type of *P. panicophila* Speg.); MEXICO: Hitchcock 5615; U. S. A.: Arthur & Fromme 5607, Clemens.

The collections have similar teliospores, varying only slightly in size and not at all in shape, but the urediospores are less constant. The form on *Panicum bulbosum*, originally segregated as *P. esclavensis*, tends to have somewhat longer, more ellipsoid

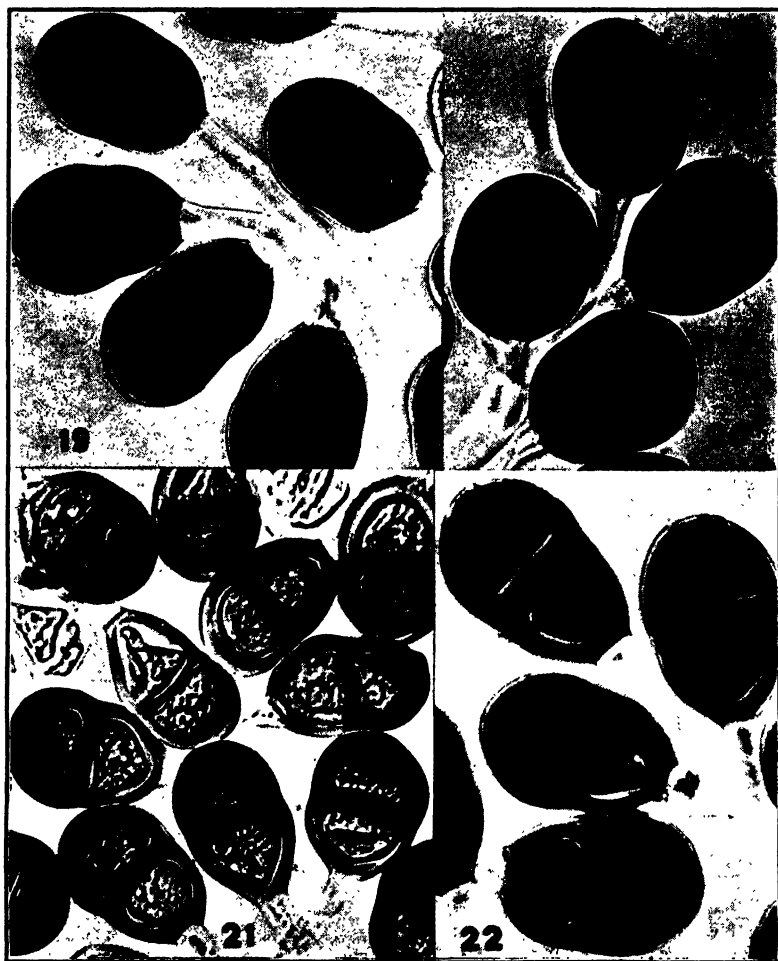


FIG. 19, teliospores of *Puccinia atra* D. & H. on *Setaria grisebachii* (from type); 20, teliospores of *Puccinia esclavensis* D. & H. (= *P. atra*) on *Panicum bulbosum* (from type); 21, teliospores of *Puccinia pseudoatra* Cum. on *Paspalum pallidum* (from type); 22, teliospores of *Puccinia panicophila* Speg. (= *P. atra*) on *Valota saccharata* (from type).  $\times 700$ .

urediospores than the type of *P. atra*. This is also true of the rust on *Pennisetum chilense* which, however, has three or four pores while the type of *P. eslavensis* usually has five or six. The collection on *Pennisetum bambusiforme* is more like the type of *P. atra*. There appears to be no reason for retaining *P. panicophila* on *Valota saccharata* as a species. North American material on the same host differs in no way.

However, the rust on *Valota insularis* is more troublesome. North American collections have urediospores with four equatorial pores or with four in the equator and one near the apex while South American collections have the pores commonly scattered and five to seven or less often equatorial and four or five. In both the spores are usually under  $30\ \mu$  in length. The arrangement of pores is in part that of *P. atra* and in part that of *P. pseudoatra*. The North American rust appears to be nearer *P. atra* while the South American rust is perhaps nearer *P. pseudoatra*. Nevertheless, I am placing them together under *P. atra*, although this may not be correct.

In his report on the Holways' South American collections Arthur (5) reported *P. atra* on *Paspalum prostratum* from Bolivia. This I consider to be *P. pseudoatra*.

PUCCINIA SETARIAE Arth. & Holw.; Holway, Bot. Gaz. 24: 28.  
1897. (FIG. 24.)

(*Dicaeoma Setariae* Arth. Résult. Sci. Congr. Bot. Vienne 344.  
1906.)

Aecial stage unknown. Uredia amphigenous or mainly hypophyllous, scattered or in linear groups, 0.5–2 mm. long, cinnamon-brown, the epidermis rupturing widely and remaining more or less conspicuous; urediospores globoid, broadly ellipsoid or less commonly ellipsoid or obovoid,  $(23-25-29 \times (27-29-34\ \mu)$ ; wall light cinnamon- or golden-brown,  $2.5-3.5\ \mu$  thick, finely and closely verrucose, the beads usually united in irregular, labyrinthiform lines; pores 7 or 8, scattered, usually evident. Telia like the uredia but blackish brown and pulvinate; teliospores ellipsoid, rounded at both ends or slightly narrowed at base, slightly or not constricted at septum,  $24-32 \times 37-48\ \mu$ ; wall chestnut-brown, smooth,  $3-5\ \mu$  thick at sides,  $8-11\ \mu$  at apex; pedicel persistent, yellowish or hyaline, moderately thick-walled, about twice as long as spore.



FIG. 23, teliospores of *Puccinia macra* Arth. & Holw. on *Paspalum candidum* (from type); 24, teliospores of *Puccinia Setariae* Diet. & Holw. on *Setaria geniculata* (from type).  $\times 700$ .

MATERIAL EXAMINED: *Setaria geniculata* (Lam.) Beauv.: ARGENTINA: Holway 2028; CHILE: Holway 290; GUATEMALA: Johnston 1699; MEXICO: Holway (type), 3126, 3156, 3556; U. S. A.: Edgerton 719.

*Puccinia Setariae* is macroscopically like *P. atra* and *P. pseudoatra* but differs from both in having larger teliospores, from *P. atra* because of consistently scattered pores, and from *P. pseudoatra* because of larger urediospores. The three species probably are closely related.

PUCCINIA HUBERI P. Henn., Hedwigia Beibl. 39: 76. 1900.  
(FIG. 11.)

(*Dicaeoma Huberi* Arth. & Fromme, N. Am. Flora 7: 287.  
1920.)

Aecial stage unknown. Uredia amphigenous, scattered in elongate brown spots, elliptic, 0.2–0.4 mm. long, pale cinnamon-brown, the epidermis rupturing by a longitudinal slit; uredio-

spores ellipsoid, broadly ellipsoid or obovoid,  $18-23 \times 20-27 \mu$ ; wall  $1.5 \mu$  thick, pale cinnamon-brown or yellowish, rather finely and sparsely echinulate; pores equatorial, 3 or 4. Telia on spots like the uredia, round or oval, 0.2–0.5 mm. long, pulvinate, chestnut-brown, the longitudinally or irregularly ruptured epidermis conspicuous; teliospores variable in size and shape, ellipsoid or clavate, frequently diorchidioid, rounded above and below or usually narrowed below, slightly constricted at septum,  $18-26 \times 24-39 \mu$ ; wall  $2 \mu$  thick at sides, thickened to  $2.5-5 \mu$  at apex but without a distinctly paler umbo, smooth; pedicel, frequently lateral, persistent, golden-brown, about one-half as long as spore. Mesospores numerous.

MATERIAL EXAMINED: *Panicum ovalifolium* Poir.: BRAZIL: Huber 3 (type). *P. trichoides* Sw.; PUERTO RICO: Clinton 119; Seaver & Chardon 1517; Stevens 82, 194, 4973, 5981, 7815, 8280, 8472, 8974; Stevenson 5029; Whetzel, Kern & Toro 2258, 2322; Whetzel & Olive 414, 415, 416, 433; VENEZUELA: Sydow (Syd., Fungi Exot. Exs. 771).

*P. Huberi* differs from the other rusts on *Panicum* in producing conspicuous, more or less striately arranged, brown, necrotic spots around the sori. The erumpent, pulvinate telia also distinguish it from *P. circumdata* while the small, mainly clavate or ellipsoid teliospores and pale urediospores are different from those of *P. levis*. *P. Puttemansii* is similar in the erumpent telia and the size and shape of its spores but the teliospores are paler, the apical wall is thicker, the thickening being in the nature of a paler differentiated umbo, and the lateral walls are thinner.

*P. Huberi* has been variously treated. Arthur (1, 3) accorded it specific rank adding, in the latter report, *P. Puttemansii* as a synonym. Arthur & Fromme (6, p. 287) treated it similarly but added as a synonym, *P. dolosa*. Then Arthur (5) removed *P. dolosa* to the synonymy of *P. substriata* and reduced *P. Huberi* and *P. Puttemansii* to synonymy under *P. levis*. Sydow (14) and Kern, Thurston and Whetzel (11) retain *P. Huberi* as a species.

PUCCINIA PUTTEMANSII P. Henn. Hedwigia 41: 105. 1902.  
(FIG. 14.)

Aecial stage unknown. Uredia scattered, amphigenous or mainly hypophyllous, oval or linear,  $0.1 \times 0.2-0.6$  mm., pale

cinnamon-brown, pulverulent, the epidermis opening by a longitudinal slit; urediospores obovoid or broadly ellipsoid,  $19-24 \times 25-31 \mu$ ; wall yellowish or pale golden-brown,  $1.5 \mu$  thick, moderately echinulate; pores equatorial, 4 or less commonly 3. Telia scattered, mainly hypophyllous, round or ellipsoid,  $0.1-0.3 \times 0.2-0.8 \text{ mm.}$ , early naked, pulvinate, chestnut-brown, the surrounding ruptured epidermis conspicuous; teliospores clavate, oblong-clavate or oblong-ellipsoid, rounded or somewhat obtuse above, narrowed below, only slightly constricted at septum,  $16-20 \times (27-30-37(-40) \mu$ ; wall light chestnut- or golden-brown,  $1.5 \mu$  thick at sides, apex thickened to  $4-7 \mu$  by a paler umbo, smooth; pedicel persistent, yellowish, equal to or less than length of spore. Mesospores occasional.

MATERIAL EXAMINED: *Panicum millegrana* Poir.: BRAZIL: Holway 1575, 1619, 1717 (Reliq. Holw. 140 as *P. levis*), 1850a, 1852a, 1921a, 1924. *P. sciurotis* Trin.; BRAZIL: Holway 1824 (Reliq. Holw. 143 as *P. tubulosa*). *P. sp.*; BRAZIL: Puttemans 140 (type).

*P. Puttemansii* was placed under *P. Huberi* by Arthur and Fromme (6, p. 287) but removed by Arthur (5) to the synonymy of *P. levis*. In this later report the Holway specimens listed above were included under *P. levis* and *P. tubulosa*. The "a" numbers were segregated from collections in which both rusts occurred in close association. This mixture was apparently obvious in the field since Holway noted in no. 1850 that two *Uredos* were present, one brown and one yellow and again in no. 1921: "with oblong, yellow-brown III." These differences are more or less obvious in dry material and, coupled with microscopic differences, make the two species easy to distinguish.

*P. Puttemansii* differs from *P. Huberi* in lacking brown necrotic spots. The teliospores are somewhat paler, have thinner side walls and thicker apex, the latter being pale and conspicuous as a more or less differentiated umbo.

As published by Arthur (5) the host of no. 1852 (see no. 1852a above) was listed as *Cymbopogon rufus*, but it is obviously a *Panicum* and apparently *P. millegrana*.

THE ARTHUR HERBARIUM,  
PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION,  
LAFAYETTE, INDIANA

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## TAXONOMIC NOTES ON MYXOMYCETES

G. W. MARTIN

(WITH 3 FIGURES)

### CALONEMA AUREUM Morgan.

Lister (Mycetozoa ed. 3: 217. 1935) says of this species: "It is closely allied to *Oligonema flavidum*, of which it appears to be hardly more than a variety." Hagelstein (Mycologia 31: 341. 1939; 32: 377. 1940) notes its resemblance to *A. nitens*, from which it differs in its more golden color and the netted capillitium, in addition to the characteristic markings of the latter. Careful examination of a large number of collections of both *O. flavidum* and *O. nitens* and of a smaller but adequate number of collections of *Calonema aureum* failed to disclose any that I should regard as intermediate. In addition to the constant presence of a capillitial net, and the characteristic capillitial markings of the *Calonema*, both capillitium and sporangium wall turn a bright pinkish orange when a weak solution of potassium hydroxide is added to a mount, whereas the only effect of this solution on any *Oligonema* is to cause a slight intensification of the yellow-brown color of the sporangium wall.

### CERATIOMYXA FRUTICULOSA (Muell.) Macbr.

Attempts have been made to distinguish species of *Ceratiomyxa* on the basis of the color of the plasmodium. On June 11, 1934, following heavy rains, *C. fruticulosa* was observed fruiting abundantly on fallen aspens in a ravine a few miles north of Iowa City. On some logs the plasmodia were colorless upon emergence, becoming milky and producing white fructifications. In about an equal number of cases the plasmodia were a brilliant yellow-green and produced greenish-yellow fructifications. The two forms were usually on separate logs, but in one instance both were emerging from the same log in close proximity to each other, although apparently not in contact. Two portions of

wood bearing plasmodia, one white and one green, were brought into the laboratory and placed in a moist chamber, with the hope that the plasmodia might be made to mingle, and perhaps fuse. This did not occur, as both proceeded to fructification, the fruitings in both cases being white and indistinguishable from each other. The yellow fruitings collected in the field, when dried in the laboratory, faded to pale ochraceous. This observation, while far from conclusive, is another suggestion that too great emphasis should not be placed on color, either of plasmodium or of fructification, in the myxomycetes.

*CERATIOMYXA SPHAEROSPERMA* Boedijn.

This minute species, originally described from Sumatra (Misc. Zool. Sumatrana 24: 1. 1927), has recently been reported from the island of Krakatoa (Boedijn, Bull. Jard. Bot. Buitenzorg III.

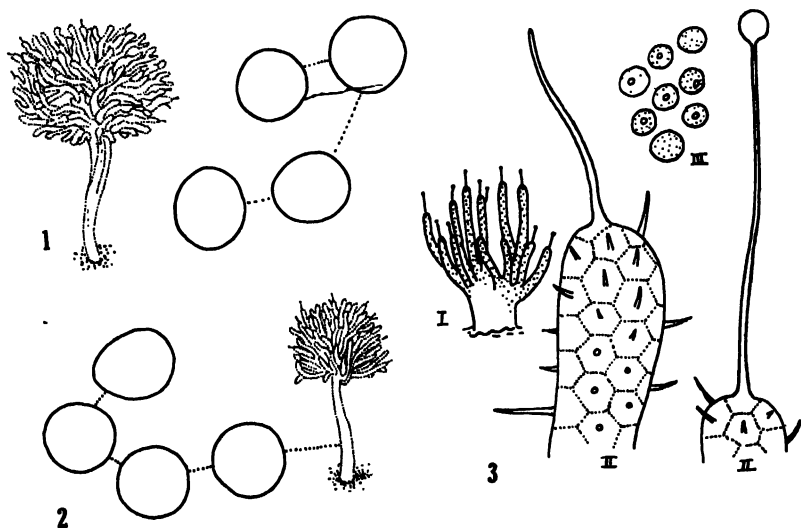


FIG. 1, *Ceratiomyxa sphaerosperma*, from Costa Rica, fructification,  $\times 20$ , spores,  $\times 1000$ ; 2, same, from Panama, same magnifications; 3, same, tracing of Boedijn's illustrations, reduced to 5/12 original size.

16: 361. 1940). Its distinctive characters are the very small, scattered fructifications, each consisting of a single stalk bearing a head of several to many nearly equal, scarcely forking branches, the rather small globose spores and the tendency for some of the



spores, particularly those borne at the tips of the branches, to be produced on exceptionally long, slender stalks. I have two collections. One (G.W.M. 4098) was collected by M. L. Shields on Barro Colorado Island, Panamá Canal Zone, August 11, 1937, on dead fruits of *Apeiba tibourbou* Aubl. and I have been holding it as a probable new species, since Boedijn's original description, published in a zoological journal of limited circulation, had escaped my notice until recently. When an additional specimen, collected by Dr. C. W. Dodge on dead wood at Castilla, Limon Province, Costa Rica, July 23, 1936 (C.W.D. 9238), reached me, I recognized it as the same species. Both the Panamá and the Costa Rica collections differ from the species as described by Boedijn in the longer, more slender stalks and the larger number of branches, but such differences are exactly those of habit which characterize developmental forms of *C. fruticulosa* and which have been the occasion for such an unfortunate multiplication of synonyms in that species. Since the distinctive microscopic characters are the same, there is every reason to suppose that the New World and the Old World forms may be referred to the same species, but not to *C. fruticulosa* or any of its varieties. Since the original description is not readily available, I add tracings of Boedijn's drawings to the illustrations of the American collections.

#### COMATRICHA ELLISII Morgan.

This species was originally described from a specimen sent to Morgan from New Jersey by J. B. Ellis. Of the four collections in the University of Iowa collection, one was sent to Macbride by Ellis and may well be a portion of the type, two are from Ohio, determined by Morgan, and one is from southern Missouri, determined by Macbride. They all clearly represent the same species. The net is open, with few anastomoses, the spores are purplish gray, minutely punctate and 10–11  $\mu$  in diameter. In Lister's MYCETOZOA in both the second and third editions, *C. Ellisii* is listed as a synonym of *C. laxa*, but Dr. Macbride believed it to be distinct. In my judgment, the disposition in the MYCETOZOA is correct, all of the specimens studied being indistinguishable from small examples of *C. laxa*.

## HEMITRICHIA MONTANA (Morg.) Macbr.

As originally described by Morgan (Jour. Cin. Soc. Nat. Hist. 18: 40. 1895) the color of this species was given as olive-yellow. In transferring the species from *Hemiarcyria* to *Hemitrichia*, Macbride (N. A. Slime-Moulds 208. 1899) rewrote the description, giving the general color as "whitish" and that of the peridium as "dull white." In the second edition (p. 266. 1922) the description was repeated without change, but it was noted that the species is "common throughout southwestern states to lower California." In spite of this latter statement, the only specimen available in the Iowa collection at the time THE MYXOMYCETES went to press (1934) was a small fragment of the type, bearing a few sporangia from which all but the basal lobes of the peridium had disappeared and hence Macbride's description and comments were repeated with slight change of wording only. What is more serious, the color attributed to the species by Macbride was used as a key character. Recently an additional and better portion of the type has been found in the Morgan collection and the color reference proves to be quite misleading. The species is, indeed, somewhat paler than most of the other yellow species, but it is neither pallid nor whitish, but rather a clear, pale yellow, while the dense capillitium is rather deep ochraceous. Seven additional collections from three distinct localities in the vicinity of Mt. Rainier, Washington, made by Dr. D. B. Creager in August, 1928, prove to belong to this species. They have been unidentified all these years largely because I was misled by the reference to the color. In none is the capillitium lighter than in the type, but unopened sporangia are numerous, and there is some variation in the peridium. It is always yellow, but in some collections very thin and almost translucent, with iridescent reflections, while in others it is more opaque and appears duller.

G. Lister (Mycetozoa ed. 2: 226. 1911), presumably after having seen a portion of the type, decided that Morgan's species was based on an irregular form of *H. clavata* and this opinion is repeated in the third edition. Our now abundant material seems to show very clearly that this is not correct. *H. montana* differs from *H. clavata* not only in exterior form, but in peridial charac-

ters, spores and capillitium. It is even less like *L. clavata* than is *H. stipitata*, which Lister also combines with *clavata* and which has been very generally and quite inexcusably misunderstood in this country. In view of the confusion, it seems desirable to rewrite the description of *H. montana*:

Sporangia gregarious or clustered, globose or obovate, sessile on a contracted base or short-stipitate, mostly 0.5–1 mm. in diameter before dehiscence, then up to 2 mm.; peridium thin, shining, translucent, or sometimes appearing dull and thicker from spore deposits, reticulate within under lens, breaking away in patches above but persisting as more or less petaloid lobes below; capillitium dense, elastic, bright ochraceous orange, becoming duller with age; elaters 6–8  $\mu$  in diameter, branching and anastomosing, with numerous free ends and vesicular enlargements; spirals five or six, rather close, bearing close-set minute spines; spores globose, bright ochraceous in mass, almost colorless under lens, minutely spinulose, 10–12  $\mu$ .

LICEA Schrad. Nov. Gen. Plant. 16: 1797, *emend.*

The original diagnosis of the genus referred to sessile species, with a thin wall, usually single, dehiscing irregularly and lacking capillitial threads among the spores. Four species are cited: *L. Tubulina*, expressly stated to be the same as *Tubifera ferruginosa* Gmel., *L. clavata*, very generally regarded as referring to a different phase of the same species, *L. variabilis* and *L. pusilla*, both of which names are still current. Since there has been some expression of doubt as to whether *L. variabilis* in Schrader's sense is the same form to which the name is today applied, it seems desirable to indicate *L. pusilla* as the type. The genus was accepted by Persoon (Syn. Meth. 195. 1801) in essentially Schrader's sense. Fries (Syst. Myc. 3: 193. 1829) revised the genus, dividing it into the "tribes" *Tubulina* (i.e. *Tubifera*), *Serpularia*, for the more or less plasmodiocarpous forms, and *Phelonitis* for two minute sporangiate species. *L. pusilla* he relegates to *Physarum* as *P. Licea*.

In his earlier work, Rostafinski (Versuch 4. 1873) recognizes *Licea* and *Tubulina* as distinct genera and maintains this in his monograph (Sluz. 201–202. 1875) citing two species in *Licea*, *L. flexuosa* Pers. and *L. variabilis* Schrad. *Licea pusilla* he

makes the type and sole representative of his new genus *Proto-derma* (Sluz. 90. 1875). Some years later Wingate established the genus *Orcadella* (Proc. Acad. Nat. Sci. Phil. 1889: 280) to accommodate a minute species which is essentially a stalked *Licea* with a lid, neither character, however, being entirely constant. Massee (Mon. 35. 1892) recombined *Licea* and *Tubulina*, under the latter name, adding to them *Lindbladia*. Shortly thereafter *Hymenobolina* Zukal (Oesterr. Bot. Zeitschr. 43: 133. 1893) and *Kleistobolus* Lippert (Verh. Zool.-Bot. Ges. Wien 44: 70. 1894) were founded to accommodate two small species which are essentially sessile Liceas with lids. Gilbert (Univ. Iowa Stud. Nat. Hist. 16: 153. 1934) described as *Hymenobolina pedicellata* a species which is essentially a stalked *Licea* without a lid, recognizing that it did not fit into either *Licea* or *Hymenobolina* as then delimited. Very recently, Hagelstein (Mycologia 34: 258. 1942) has proposed uniting *Kleistobolus* and *Hymenobolina* with *Orcadella*. I have long been of the opinion, not only that these three genera are based on inadequate distinctions, but that they should be united with *Licea*. The presence or absence of a stalk is not usually regarded as a generic difference and the presence or absence of a definite lid is scarcely of greater significance. The latter character, it is true, is used to separate *Craterium* from *Physarum* and, with the addition of a typical plasmodiocarpous fructification, *Perichaena* from *Ophiotheca*. Neither of these instances affords a particularly good precedent. In the former case, it is admittedly artificial and justified, not because it is believed to represent any fundamental distinction, but purely by the convenience of separating a fairly coherent group of species from a large and complex genus. In the latter case, even with the additional character, it is not regarded as significant, and the Lister monograph, with much justification, combines the two genera. In my experience, the presence of a lid, while constant in *Kleistobolus*, is far less so in *Hymenobolina parasitica* or *Orcadella operculata*, although the last-named species is much less common with us than the other two and hence I have had less opportunity to observe it. Likewise, the stalked character in *Orcadella* and in *Hymenobolina pedicellata* is admittedly inconstant.

I therefore propose that the genus *Licea* be emended to include all Myxomycetes with separate, limeless, sporangiate or plasmodiocarpous fructifications, sessile or stalked, dehiscent irregularly, by plates or by lids and lacking a massive hypothallus and capillitium, other than the finger-like protrusions from the inside of the cap in *Kleistobolus*. As thus emended, the genus is close to *Tubifera*, the latter differing in its massive hypothallus upon which the sporangia are closely packed or heaped, characteristically forming a pseudoaethalium.

The following transfers are proposed: *Licea operculata* (Wing.) comb. nov.; *Licea parasitica* (Zukal) comb. nov.; *Licea pedicellata* Gilbert, comb. nov. The transfer of *Hymenobolina pedicellata* to *Licea* under Dr. Gilbert's name is with his consent and approval, expressed some years ago.

Since *Licea pusilla* Schrad. is already in existence, I propose for *Kleistobolus pusillus* the combination *Licea Kleistobolus* nom. nov.

The family Liceaceae should be enlarged to include *Tubifera*, since the massive hypothallus and pseudoaethalial habit of the latter genus, while useful generic characters, do not deserve to be considered as a sufficient basis for segregation into a distinct family. *Alwisia* and *Liceopsis* need further study before their position can be more than tentatively fixed.

In the article cited, Hagelstein objects to considering in taxonomic work results secured in cultures "until fully substantiated." Just what this means is not clear. Certainly all will agree that it is highly undesirable to publish any work until reasonable care has been taken to make sure that it is correct. But if it be intended to imply that only Myxomycetes collected in the open are to be regarded as a satisfactory basis for taxonomic study of the group, I must emphatically dissent. Some cultural developments, it is true, are highly aberrant; so are many fruitings found in the open. I have been bringing slime molds to fructification in moist chambers for many years, and I have seen so many different species come to perfect fruiting under such circumstances that I have come to regard such cultures as an invaluable adjunct to the study of the field material. Not only are the fruitings frequently more perfect than those

collected outside but a number of species, especially minute ones rarely seen in the field and previously supposed to be uncommon, have been shown to be abundant and widely distributed. Among such are *Licea parasitica* and *L. Kleistobolus* mentioned above, as well as *Licea biforis*, *Clastoderma Debaryanum*, *Comatricha fimbriata* and *Echinostelium minutum*. Furthermore, observation of developing fructifications under such circumstances often yields information of considerable significance. Thus it seems perfectly true that some species, of which *Licea pedicellata* and *L. operculata* are examples, ordinarily arise from small plasmodia, giving rise to one or a few fructifications. What I regard as more significant is that several of these small species, notably *L. minima*, *L. parasitica* and *L. Kleistobolus*, have rather extensive plasmodia in the substratum, but the plasmodia do not emerge to the surface as in more highly developed species, but, when ready to fruit, send out through the pores of the substratum individual droplets of protoplasm, each of which will form a separate sporangium. Emergence, in these species, is clearly a part of the fruiting process.

#### PHYSARUM BETHELII Macbr. ex List.

Sturgis (Colo. Coll. Pub. Sc. ser. 12: 439. 1913) and Lister (Mycetozoa ed. 3. 36. 1925) concur in regarding this species as a variety of *P. viride* (Bull.) Pers. Brandza, however, regards it as distinct (Bull. Soc. Myc. Fr. 44: 256. 1929). On the basis of the material available for study I cannot agree that *Bethelii* is no more than a variety of *viride*. *P. viride* is, it is true, highly variable, as is often the case with common and widely distributed species, nevertheless I find nothing in our abundant material which I should regard as merging into *Bethelii*. On the other hand, certain specimens determined as *P. Bethelii*, or as *P. viride* var. *Bethelii*, seem to me to represent *viride* and to be scarcely worthy of varietal segregation. In what I take to be the type collection of *P. Bethelii*, of which Lister's plate 200a is an accurate representation, the stipe is short, the peridium is nearly limeless and iridescent blue, the lower portion remaining as a cup, the capillitium is paler than is usual in *viride* and arises

from the inserted base of the stipe in such a way as almost to suggest a columella, and the spores are slightly larger and more distinctly warted than those of *viride*.

In addition to the Colorado collection, presumed to be part of the type, we have a small, but typical gathering from Washington.

STATE UNIVERSITY OF IOWA,  
IOWA CITY

## NOTES AND BRIEF ARTICLES

### "THE ADVENTURE OF THE ARDENT MYCOLOGIST"

To some of us mycology is a profession or a semi-profession. To others, who have a real profession, mycology or mycophagy is pursued merely as a hobby. This is true of a recent caller in our office, Mr. Percival Wilde, well known author and playwright, who during his periods of relaxation plays with the fungi. In his latest book "Tinsley's Bones" he has devoted a chapter to the above title in which he depicts some of the idiosyncrasies of an ardent and rather absent minded, which is to say, typical mycologist. Professional mycologists during their periods of relaxation would very much enjoy reading this, as well as the remainder of the book.—FRED J. SEAVER.

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### OCCURRENCE OF *GONATORRHODIELLA* *HIGHLEI* IN NOVA SCOTIA AND NEW BRUNSWICK

In his recent paper (*Mycologia* 33: 178-187. 1941.), Ayers reported *Gonatorrhodiella Highlei* A. L. Smith growing in association with *Nectria coccinea* (Pers. ex Fries) Fries and the woolly beech scale (*Cryptococcus Fagi* (Baer.)) on diseased American beech (*Fagus grandifolia* Ehrh.) in Maine. Therefore, it is thought of interest to record that *G. Highlei* (determinations checked recently by Ayers) occurred under similar circumstances in affected beech stands throughout Nova Scotia and in Albert County, New Brunswick, during the summers of 1930, 1931, and 1932.

In answer to a question addressed early in 1942 to R. E. Balch of the Dominion Entomological at Fredericton, N. B., he replied as follows. ". . . The brown mold can, I think, be found wherever heavy infestations of the scale occur. . . . It has not been noted on scale-infested trees as invariably as the *Nectria*. . . . I know that the mold occurs at Fredericton, but I cannot be sure that it has been collected north of here."—JOHN EHRLICH.



# MYCOLOGICAL SOCIETY OF AMERICA

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MILES, DR. LEE ELLIS

## FINANCIAL STATEMENT

December 31, 1940–December 31, 1941

## Balance on hand Dec. 31, 1940

|                                    |           |
|------------------------------------|-----------|
| Cash .....                         | \$ 734.38 |
| Government Bonds.....              | 200.00    |
| Savings account (as of 1939) ..... | 500.00    |

## Receipts

|   |         |
|---|---------|
| Annual dues in part 1940, 1941 .....          | 1847.74 |
| Interest on Savings account (since 1939)..... | 18.57   |

## Expenditures

|  |           |
|--|-----------|
| New York Botanical Garden for Mycologia..... | \$1503.00 |
| Returned checks .....                        | 25.50     |
| Postage and envelopes .....                  | 41.80     |
| Secretarial help .....                       | 11.48     |
| Yearbook notices .....                       | 3.25      |
| New York Botanical Garden for yearbook.....  | 112.00    |
| Mimeographing .....                          | 12.96     |
| Telephone and telegraph .....                | 5.07      |
| Programs for Dallas meeting.....             | 29.75     |
| Sect'y's travelling exp. to Phila.....       | 59.14     |
| Biologists smoker.....                       | 10.00     |
| State tax on Bank Deposits.....              | 1.25      |

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 \$1815.20

## Balance on hand Dec. 31, 1941

|                       |           |
|-----------------------|-----------|
| Cash.....             | \$ 766.92 |
| Government Bonds..... | 200.00    |
| Savings account.....  | 518.57    |

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 \$3300.69 \$3300.69
(Signed) J. N. COUCH, *Secretary-Treasurer*

Examined and found correct:

DELBERT SWARTZ, *Chairman of Auditing Committee*

DALLAS, TEXAS, Dec. 29, 1941

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